Care or Self-Care - Minority Women in Cycling

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Abstract. The gender, racial, and socioeconomic inequalities in active travel are well documented (Lam, 2022). Recent macro-studies (Goel, Goodman, et al., 2022; Goel, Oyebode, et al., 2022a) on gender and active travel show the widespread gender inequality and highlight the existing disparity in the cycling uptake by women in countries with a low cycling modal share, like London. While studies exploring aspects of cycling have seen a marked increase in the last two decades (Pucher and Buehler, 2017) there is a conspicuous lack of literature on sub-groups such as ethnic minority cyclists and especially ethnic minority women. This work seeks to illuminate mobility and the role of visualization in uncovering hidden powers and unseen realities of female ethnic minorities and answer the question: "Can visualizing and digitizing the cycling movement, combined with qualitative methods help us uncover the cycling context of ethnic minorities women that use bicycles and gain new insights into context of and their relationship with cycling?". It is doing that by developing a visual presentation method tailored to enable maximum exploration of the individual, recorded journeys. The aim of the paper is to present the method and to demonstrate its ability to extract new insights. The importance of the work lies in the fact that we need a better understanding of realities of female mobility in order to inform future work on urban development and the promotion of cycling. By focusing on the specific sub-group, Muslim and BAME (Black, Asian, and Minority Ethnic) women cyclists, this work aims to get away from dominant voices and representations and reach the invisible and overlooked. To achieve this, I worked with a small group of ethnic minority women, who kept a diary of their cycling experience and used a GPS tracker for logging their cycling over a period of two weeks. The data they collected was presented back to them as an interactive individual data notebook that contained visual modelling of their journeys and the diary prompts.

This combination of technology, visualization, and a qualitative approach has revealed that contrary to expectations, the way women move in their environment has been misunderstood as it primarily serves as a means of self-care and not care for others.

This empirical work presents a new framing for considering the way female cyclists use their environment and what this environment needs to offer. It is giving a voice to the growing and vibrant cycling undercurrent of ethnic minority women in active travel as well as engaging the citizens-action groups that are supporting mobility (r)evolution.

1 Introduction

The growing recognition of the advantages associated with active travel (Oja *et al.*, 2011; Panis, 2011; Handy, van Wee and Kroesen, 2014) has sparked a surge in interest in cycling and other forms of active transportation. This resurgence has led to a substantial and diverse body of research. The number of scholarly publications on cycling has increased by thirteen times between 1995 and 2016 (Pucher and Buehler, 2017), covering a wide range of topics and perspectives. These encompass studies on infrastructure development (Alta, 2017; Moran *et al.*, 2018), diversity in cycling (Aldred and Dales, 2017), and the portrayal of cycling in the media (Caimotto, 2020), among others.

Londoner's travel habits have been changed by the COVID-19 pandemic, which has also impacted attitudes towards cycling (Department for Transport, 2021). There has been an increase in cycling, particularly among minority communities in terms of gender and ethnicity. While the primary reason for this increased uptake is attributed to reduced traffic levels (Hong, McArthur and Raturi, 2020a; Nikitas *et al.*, 2021), it is evident that the pandemic has had a broader impact, influencing various aspects of life, including family dynamics (Nicola, Ruspini and Nicola, 2020), work conventions and the inclination to explore new behaviours and practices (Figus, 2020). Still, the numbers are small as cycling accounts for only 27% of the trips made in the capital and out of that 27%, only 17% is made by ethnic minorities. There are no numbers on how many of those are female but we do know that over 75% overall are male. The numbers on ethnicity are especially surprising if we take into account that the recent population census has found that London is the most diverse place in the UK with 47% of its population identifying as an ethnic minority. All of this indicates that there is a misalignment between the potential and uptake when it comes to cycling. It also indicates that current measures for promoting and encouraging cycling are not meeting their target.

Given the aforementioned changes and the multitude of factors influencing them, conducting research on cycling practices and individuals' role in the active travel landscape is crucial to sustain and capitalize on the momentum gained during the COVID-19 period. However, it is essential that this research goes beyond the confines of the pandemic and employs methodologies that allow for the identification of meaningful indicators and trends in everyone's cycling experiences, which can be adapted and applied flexibly. This project asks, if visualizing and digitizing the cycling movement, combined with qualitative methods can help us uncover the cycling context of ethnic minority women who use bicycles and gain new insights into the context of and their relationship with cycling. We propose the methodology for capturing and presenting movement that surrogates the cycling experience and maintains a link to quantitative data during qualitative interviews, thus situating the riding experience and giving us new insights into the realities of the subject's movements and the motivations for their choices.

Exploration of Diversity in Cycling

Even before the pandemic, government bodies had already begun acknowledging the importance of active travel and implementing measures to reduce reliance on cars and fossil fuel-powered vehicles. The literature consistently highlights good infrastructure and safety as key factors influencing the likelihood of cycling uptake (Pucher, 2001; Jacobsen, 2003). However, despite publicized investments in infrastructure, Transport for London's (TfL) report (Transport for London, 2018) indicates that there was no significant increase in the number of new cyclists prior to the COVID-19 pandemic. The report reveals that the overall distance travelled by bicycle has indeed increased, but this can mainly be attributed to existing cyclists embarking on longer journeys. Additionally, research by Aldred and Dales (Aldred and Dales, 2017) suggests that improving infrastructure does not have a substantial impact on diversifying the demographic composition of the cycling population, which continues to be predominantly young males. The comparison of cycling census data from 2001 and 2011, along with corresponding infrastructure developments, reinforces the finding that women are among the groups whose cycling rates do not significantly increase in response to improved infrastructure. This observation is supported by Lam's examination of cycling advocacy and policy-making in Hackney, a London borough known for its high cycling levels (Lam, 2018), as well as Steinbach *et al.*'s (Steinbach *et al.*, 2011) study on the correlation between ethnicity, class, gender, and cycling propensity among London cyclists. Despite countries with well-developed cycling infrastructure demonstrating greater diversity and gender balance in cycling (Goel, Goodman, *et al.*, 2022), the incremental improvement in infrastructure provision in London appears to be less effective in promoting diversification. Consequently, additional factors are required to complement infrastructure development

efforts in order to achieve a more diverse cycling population. Lam (Lam, 2018) challenges the decision-making process of allocation and placing the cycling infrastructure in a radial model, which prioritizes one type of journey (an economic commute) overlooking the population's diversity of needs and functions. Lam asserts that diversity is revealed when quantitative information is contextualised, which can be achieved by complementing it with qualitative methods. This thinking is echoed by Krizek (Krizek, 2018) who takes the position that determining the cycling benefit necessitates uncovering the distinctive elements within the cycling journey and going beyond the functional characteristics.

Some methodological advances have been made, for example, the work of *Gamble et al.* (Gamble, Snizek and Nielsen, 2017) which augments the quantitative data with photographic evidence and diary. While this is a move towards situating the data, the approach requires the time, persistence, and dedication found in advocacy. Thus, it does not address the issues of lack of intersectionality, gender equality, and ethnic representation in cycling research that Lam has raised (Lam, 2018).

Cycling and Visualisation

Cycling and visualization have a long-standing and interconnected relationship that encompasses various aspects. This association extends from the utilization of visualization techniques integrated into fitness devices, as discussed by Niess *et al.* (Niess *et al.*, 2020), to the more comprehensive exploration of movement patterns through visual analysis, as examined by Beecham, Wood and Bowerman (2014).

In the realm of fitness devices, visualization plays a crucial role in enhancing the cycling experience, as highlighted by Niess *et al.* (2020). The visualizations on the devices provide cyclists with real-time feedback on their performance metrics, such as speed, distance covered, and heart rate. Thus, users can monitor their progress, set goals, and adjust their training accordingly. This integration of visualization within fitness devices creates a symbiotic relationship between cyclists and their data, some would argue, facilitating a more informed and optimized exercise experience.

Beecham and Wood perform a visual analysis of urban movement patterns (Beecham, Wood and Bowerman, 2014) and use origin-destination data of city rental bicycle schemes. They combine it with other available data to gain insights into the movement, effects of the urban landscape, economic positions of users, and differences in gendered approaches as well as creating animations that explore the evolution of the hire cycling journeys, providing information on the frequency, directionality, and seasonality of cycling locations (Beecham and Wood, 2014).

Cycling and Geography

Geography is the study of the environment we inhabit. It recognizes the distinction between space, which is measurable, and place which reflects human interaction and the experience (Agnew, 2011). Works in urban geography position cities in relation to sustainability (Spinney, 2020a), health (Waitt and Buchanan, 2023), uptake of cycling, and active travel (Aldred, Croft and Goodman, 2018) among others.

But the story of geography is often a story of borders and cycling takes us across borders. It traverses, intersects, touches, and glides through familiar as well as new spaces and locations. In sprawling urban settings like London, cycling routes can vary, with cyclists sometimes opting for the shortest path, other times choosing the least hilly route, and occasionally sticking to designated cycling paths. Thus in complex urban environments, such as London, people who cycle, and their experiences are difficult to capture and measure, and what we often get is fractured and incomplete. We used maps as a substitute for actual journeys, enabling exploration with fewer spatial limitations and boundaries. However, it's important to recognize that maps themselves encode and possess their own expression and representation of the world they depict. They shape and influence the experiences of individuals who interact with them, presenting both possibilities and constraints.

Women and Cycling

In the research literature, female cyclists tend to be associated with journeys of care (Ravensbergen, Buliung and Sersli, 2020; Spinney, 2020; Goel, Oyebode, *et al.*, 2022). Journeys of care are outings that are made in order to take care of dependants, such as children or elderly, and for purposes of domesticity. They differ from commuting cycling in that they are local and more fragmented as they often contain a number of stops. This practice is called trip-chaining (Ravensbergen, Buliung and Laliberté, 2019). London's radial cycling infrastructure, which supports commuting, does not allow for this type of journey (Criado-Perez, 2019; Spinney, 2020; Lam, 2022). There is some evidence that journeys of care, and their challenges are one of the causes of low female cycling uptake (Criado-Perez, 2019; Ravensbergen, Buliung and Laliberté, 2019).

In her work, Criado-Perez (Criado-Perez, 2019) has discussed the prevalence of gender bias in research and in practice. Her work looks at who has a voice and who is enabled. If, in that context, we consider that only 27% of cyclists in London are women, this poses a question of recognition and equality. Who has a voice and who is enabled? If intersectionality explores how our identities influence our capabilities, in the context of cycling, it appears that being a woman predisposes you not to participate in cycling.

Our understanding and familiarity with attitudes and manner of cycling when it comes to what is considered minority populations is even more limited. The number of research studies is small and often relies on a mixture of literature review, examination of policy documents, and opinions extracted from interviews (Lam, 2018), surveys (Spinney, 2020), or counting (Emond, Tang and Handy, 2009) (Hong, McArthur and Raturi, 2020). Some works strive to adopt a more holistic approach and marry disparate data sets from a variety of sources. Goel *et al.* (Goel, Goodman, *et al.*, 2022) look at 19 cities and their active travel data in order to compare and extract insights. Their findings are that women's mobility is shaped by their care responsibilities and social norms. Women are, overall, 5% more active than men and complete more journeys by active travel methods. Despite this, they cycle less than men, except in high-cycling environments, where men and women cycle equally.

In their work, Song, Kirch and Taylor's (Song, Kirschen and Taylor, 2019) interviewed participants in Solo, Indonesia to identify barriers for women such as access to bicycles and the appropriate infrastructure, as well as feelings of vulnerability while on the bicycle. In conclusion, there is a lack of comprehensive research that adequately represents and recognizes ethnic minority cyclists despite acknowledgment that ethnicity and cultural practices play a role in the way people choose to interact with their environment. We haven't got a reliable method to extract such knowledge and little insight into the subgroup's habits and attitudes. This project suggests one method that encompasses data collection, presentation, and analysis.

2 Methods

To address points raised in the previous chapter, we approach a volunteer organization supporting female cycling and whose membership largely consists of ethnic minority women. We recruited cross-sectionally wanting to capture a range of cycling competencies. Data gathering lasted two weeks, during which the participants were asked to use a GPS tracker in order to log their cycling journeys and fill in a twice-daily short survey diary. The GPS gave us a snapshot of all cycling activities without unintentional bias which is often present in surveys and interviews (Heckman, 2013). Thus gathered data was then transformed into the data notebook containing an interactive representation of the journeys made during the data collection period. The notebook, and the visualizations it contained, were used as elicitation prompts and were the basis for the individual interview which was then analysed using thematic analysis (Braun and Clarke, 2013).

2.1 Recruitment

We have established that in London women, and especially ethnic minority women are an unrepresented among the cyclists. In the best of circumstances, finding dedicated participants is a challenge, compounded in this case by the small size and dispersion of this subgroup.

One of the ways to mitigate this dearth is to engage with organizations working with relevant communities. In London, there are specific cycling groups working with women, especially women from minority backgrounds that offer support and focus. We engaged with one of the mentioned female cycling groups (FCG) and took part in their activities, which enabled us to conduct targeted cross-sectional sampling (Faugier and Sargeant, 1997). In order to protect the confidentiality and anonymity of the organization, as well as the individuals involved, the names, and certain minor details pertaining to the participants have been altered.

The project had a three-month data-gathering timeline and budget for two devices, which limited us to seven participants. The participants were of varying cycling skill levels, where four could be classified as intermediate cyclists, two as experienced, and one as beginner (Fig. 1).

Cycling proficiency	Number of participants
Intermediate	4
Experienced/advocate	2
Beginner	1

Figure 1: Participants had varied cycling proficiency. 60% of participants were intermediate cyclists, with 30% advanced and 10% at the beginner skill level.

2.2 Data Collection

Due to concerns over privacy and GDPR (General Data Protection Regulation which ensures rights and the privacy of individuals are protected) data compliance (Gu *et al.*, 2017; Bishop *et al.*, 2020; Hassandoust, Akhlaghpour and Johnston, 2021) we decided not to utilize commercial mobile applications with tracking capabilities such as Strava or Kamoot. While some studies develop custom applications, which gives them greater control over what and how data is collected (Tamura *et al.*, 2019; Boakye *et al.*, 2021), this requires a large time investment that we did not have at our disposal. For those reasons, we opted for passive collection using a cycling personal computer Elemnt Bolt tracker. The metrics we were interested in collecting were time, longitude, and latitude.

We used the GPS Visualiser (Schneider, 2019), an online data management tool to smooth the data, convert it into the desired format (from .fit to .gpx), and extrapolate the speed. The smoothing was achieved using the Kalman smoothing algorithm due to the method's stability and its ability to faithfully capture the desired data systems (Zhou *et al.*, 2019; Boakye *et al.*, 2021).

2.2.1 Survey-diary

A diary keeping is a popular data collection method for gathering insight into individuals' habits and thinking (Gunthert and Wenze, 2012). When it comes to mobility studies, diaries tend to accompany movement data collection (Handy, van Wee and Kroesen, 2014; Neves and Brand, 2019). We used diaries as a memory jogger and to contextualize the GPS data.

The surveys were sent in the morning and in the evening (at the pre-agreed time). The morning diary asked about participants' cycling plans and the evening survey asked for a report of the actual cycling done. The reasoning was that this would capture the days when participants encountered barriers to cycling (unrealized plans), as well as spontaneous and opportunistic journeys. In anticipation of trip-chaining (Ravensbergen, Buliung and Sersli, 2020), participants were asked about the number of stops they were planning/made. Other questions were the category of the journey, whether they cycled in company, and a memory jogger comment/word.

2.3 Data Notebook

Data notebooks are computing environments that integrate interaction and easy access to data. They are flexible in that they usually facilitate the use of different coding languages, as well as the import of libraries. One of their major advantages is the ability to include plain text passages with the code outputs, which enables better communication between users of the notebook and its creators (Wood, Kachkaev and Dykes, 2019).
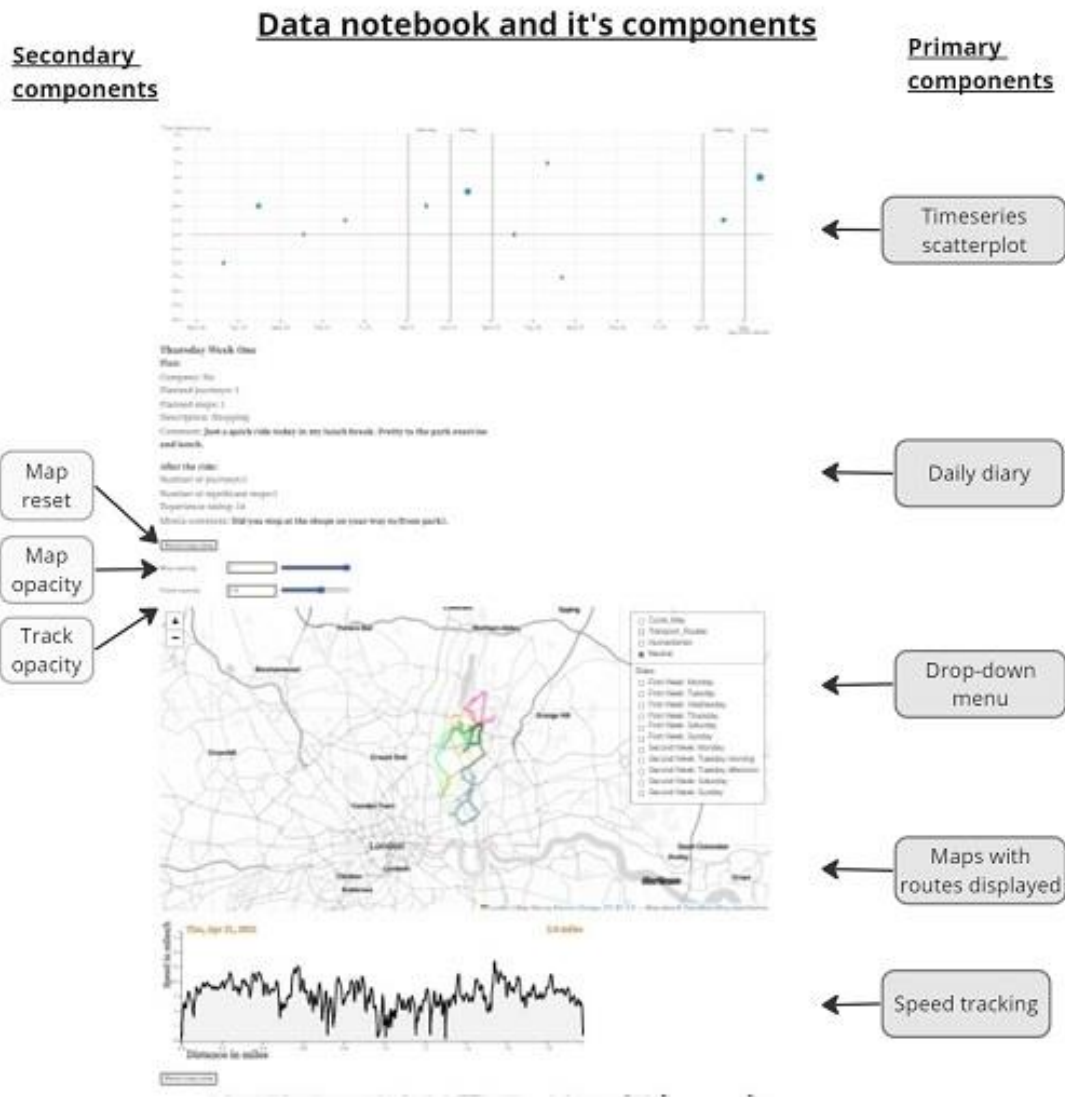
Figure 2: Data notebook with the primary and secondary components.

We have chosen Observable (Bostock, 2017) for this project as it has facilitated the development of an interconnected system of interdependent and branching pages. This ecosystem has allowed for efficient data manipulation and customization of data presentation, while also providing control over processes within a reactive environment. The use of Observable has provided a versatile and dynamic framework for achieving the project's goals. It enabled us to incorporate the daily survey diary and create a design that would foster recollection and enable exploration.

2.4 Design and Map Choices

The notebook design contained primary and secondary components (Fig 2). The primary components were the time-series scatterplot which presented temporal placement and the duration of the rides; the display of the survey-diary entries; map space with the display of the routes; the drop-down menu that enabled participants to view rides in isolation and manage the base map display; and the speed tracking scatterplot. The secondary components had a supporting function and they were map reset as well as map and track opacity buttons.

As our previous work has shown that base maps play a role in recollection and association, the participants were enabled to change between four representations, each with their own embeddings.

Figure 3a: Example of Humanitarian map

Figure 3b: Example of Stamen Light map

Figure 3c: Example of Transport OSM map

Figure 3d: Example of Cycle OSM map

Figure 3: Examples of the four types of a map used in the data notebook.
All the examples use the same geographical area.

2.4.1 The Maps

The selection of maps in the data notebook has been intentionally limited to avoid overwhelming the participants and to ensure clarity in the analysis process. The chosen maps have been carefully selected based on the specific information they convey and their visual characteristics. This approach allows for focused and effective analysis while providing participants with clear and meaningful visual representations of the data.

When creating the maps, three categories of attributes were considered.

1. **Information that it relates** - all the maps differ in what they capture as well as the spatial layout of the area. This is in increasing complexity from the Stamen Light map (this map will also be referred to as 'neutral' in the following text) to the OSM Cycle map. Each map offers a different environment.
2. **Visual Clutter** - Visual clutter is an agglomeration of features in an image and its calculation can be achieved in a variety of ways (as a number of distinct objects, number of contrasting hues, number of vertices in an image etc.). Due to its effect on the participant's ability to segment the visual presentation, it has an impact on interpretation and engagement (Rosenholtz, Li and Nakano, 2007). However, visual clutter is subjective and difficult to define in tasks with interactive and dynamic geographical representations.

Based on these considerations, we chose the following four maps:

Stamen Toner maps are black-and-white maps, which are ideal for overlaying data and visualizations. We chose Stamen Toner Light as it is neutral, unobtrusive, and devoid of extra features that could influence the participant's narrative (Fig 3a).

OSM transport map is specifically designed to showcase transportation features and information derived from OSM data. Its primary purpose is to highlight details pertaining to transportation infrastructure, including roads, highways, railways, and various public transportation systems such as buses and subways. Anecdotal evidence shows that novice cyclists often follow bus routes and use other public transport features for orientation (Fig 3c).

Humanitarian map aids disaster response and humanitarian efforts. It identifies infrastructure, resources, and transportation routes. Volunteers worldwide update it in real time using satellite imagery. It improves effectiveness and efficiency in relief efforts. The map's features are designed for offline use in areas without electricity and to be a base map for rescue and relief efforts. It has a muted color scheme and local details which are considered important for orientation (Fig. 3a)

OSM Cycle Map This map clearly marks cycle lanes, cycle parking, A-roads, and high roads. It includes cycle-specific icons like bike repair, water stations, cycle furniture, and rain shelters. However, it has the highest visual clutter (Rosenholtz, Li and Nakano, 2007), strong hues, and large contrasts. Clutter in this context refers to the visual appearance and number of features competing for attention, not the choice of content or its usefulness.

2.4.2 The visualization of cycling frequency and cycling trends

A time series scatter plot was created to visualize the time and duration of all recorded rides during the two-week period. The purpose of this plot was to help participants identify trends and assist in remembering their cycling activities.

The data used for the time series scatter plot consisted of recorded ride dates and times. The dates were in UTC format and were used to extract attributes such as duration, time of day, and day of the week.

In the resulting scatter plot (Fig, 5) the position encoded the date and time, while the magnitude of the circles represented the length of the recordings. The time series scatter plot provided a visually informative representation of the recorded rides, incorporating design principles of 'maximum information per ink ratio that promotes comparison and relationships' (Munzner, 2014) to enhance clarity and understanding.
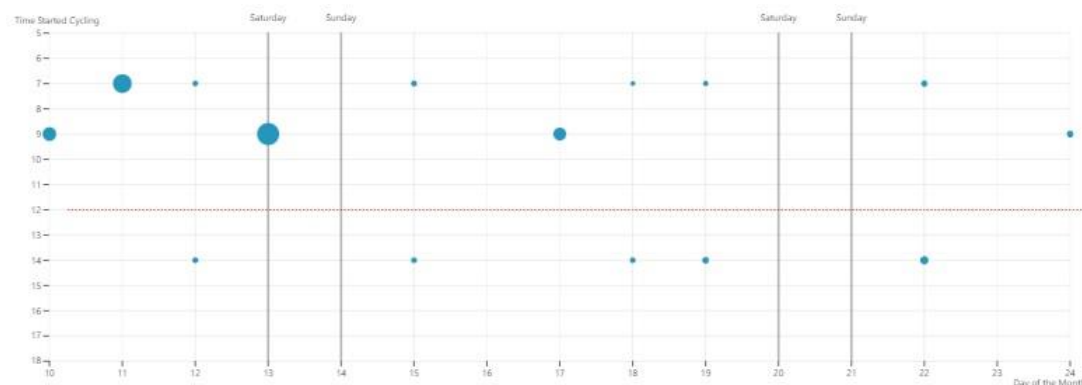
Figure 4: The scatter plot of cycling activity per day, with the duration with the dates on the x-axis and the time of day on the y-axis.

The distance between the design elements matters and the research has shown that the excessive need for scrolling leads to disengagement (Fessenden, 2018). Hence, two versions of the maps was develop and placed in positions that would make them accessible and aid interpretation during the interaction with the maps.

2.4.3 Speed Tracking

The measurement of cycling speed is often used for performance tracking and comparison (Craig and Norton, 2001; Douglas, 2021), while the analysis of the number of stops made by cyclists helps contextualize their interactions with other road users (Börjesson *et al.*, 2018). In a study by Parajito *et al.*, speed and geo-location data were combined to identify friction locations and their characteristics in three European cities (Pajarito and Gould, 2018).

In the context of this study involving women participants, identifying stops can provide insights into trip-chaining behavior associated with female mobility (Schneider, Daamen and Hoogendoorn, 2022). To facilitate the recognition and identification of stops, participants were instructed to record significant stops in their daily diaries. Additionally, their speed data was plotted on a line chart positioned below the map. An interactive feature was implemented to enable cross-filtering (Psallidas and Wu, 2018; Schneider, Daamen and Hoogendoorn, 2022), where selecting a point on the speed line chart would highlight the corresponding location on the route map.

The top map includes two additional markers: a green circle representing the start of the recording and a red circle indicating the endpoint (Fig 5).
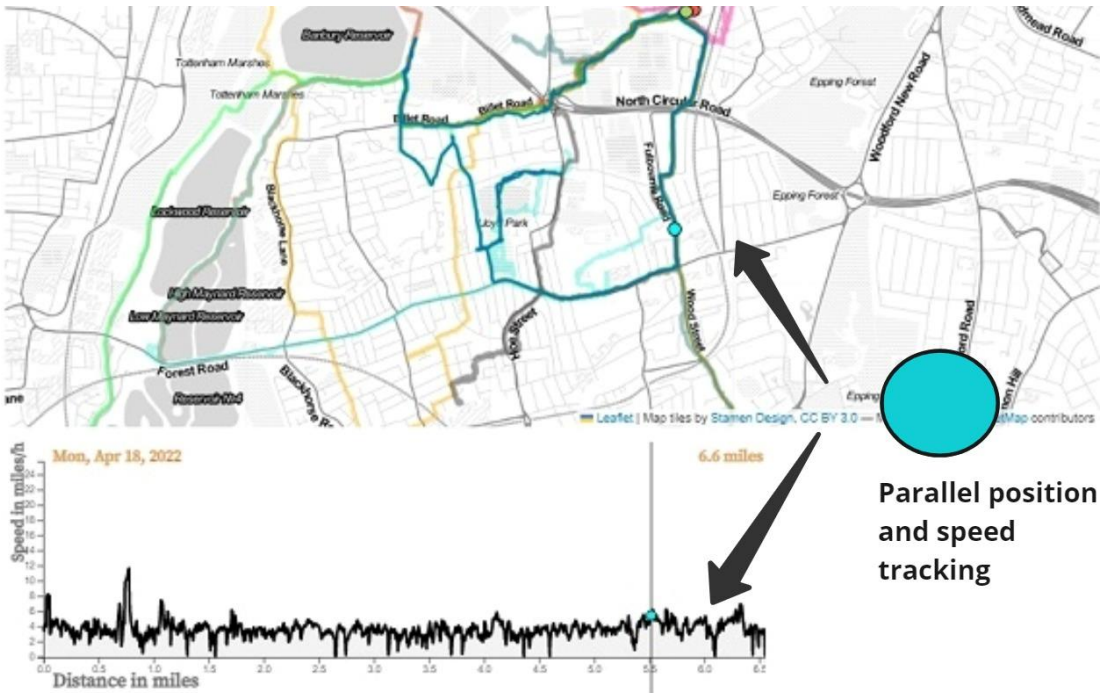

Figure 5: Data notebook detail - speed tracking. The map displayed the route taken and the line chart displayed the speed. The participants were able to relate position with the speed by moving the mouse along the line chart. This displayed as a blue circle and moved a corresponding circle on the map. The blue circle above the text in this image is a magnified version of the circles used and it is present in this image only for illustration purposes.

2.3.5 Layers control

The data notebook incorporates map sections with multiple tile layers and GPS data to provide a visual representation of geographic information (Jordan and Henderson, 1995). GPS routes captured from participants' recorded cycle rides are displayed on the map, showing location and movement, along with additional metadata such as timestamps, speed, and direction.

Users have manual control over the maps and GPS routes, allowing them to zoom in and out, pan around, and toggle between different layers (Nguyen, Colman and Han, 2013). The representation includes interactive features such as dropdown menus and checkboxes. Dropdown menus enable users to select base maps, while checkboxes allow for the selection and display of individual or multiple rides (Fig. 6a) (Psallidas and Wu, 2018). Automated reset buttons are available to re-centre the maps, and sliders control the opacity of non-highlighted journeys and facilitate data exploration (Nguyen, Colman and Han, 2013).

The integration of GPS routes and map layers in the data notebook provides a comprehensive and interactive visualization tool for analysing and exploring participants' recorded rides (Jordan and Henderson, 1995; Psallidas and Wu, 2018).
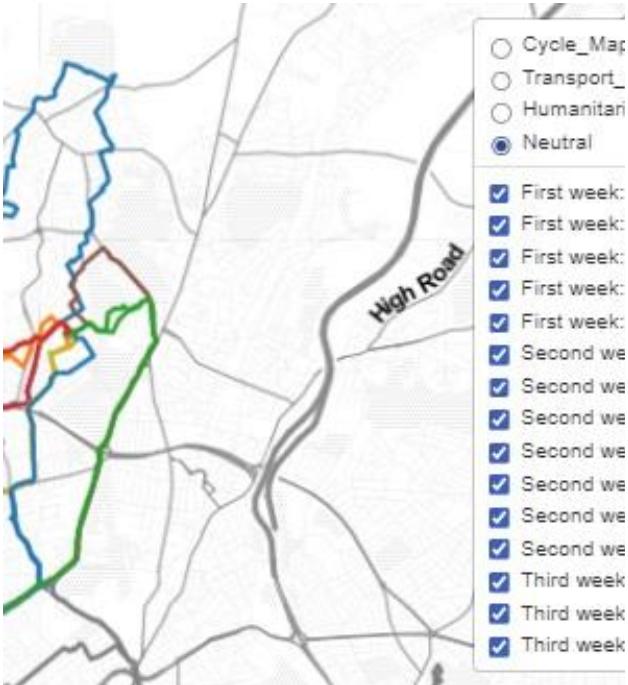
Figure 6a: A drop menu that enables multiple journey selection.
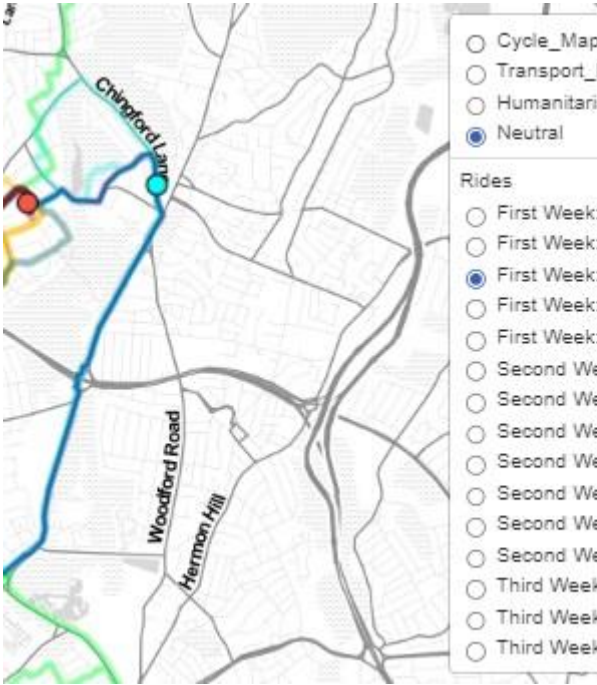
Figure 6b: drop menu for a single journey selection.

Figure 6: Participants had a choice of base maps as well whether to view a single journey or several journeys simultaneously.

3 Analysis

The analysis was performed on the content of the interviews and the actions and interactions with the data notebook.

The interviews were transcribed and examined in the combination with the screen capture recordings. We performed thematic analysis (Braun and Clarke, 2013) supported by NVivo software.

The next section presents two illustrative examples, followed by an analysis of the overall cohort's outcomes.

3.1 Two Case Studies of Participant Interaction: Ethnographic Analysis and Individual Outcomes

Participants in this study had varied riding experiences and we are presenting two case studies of; one at each side of the spectrum; a cycling advocate and a novice.

3.1.1 The Case of a Cycling Advocate: Amira

"If I would have to change the job and it was closer to home, I would leave half an hour early to give myself time to cycle"

Amira is an avid cyclist, and cycling is an important part of her life. She is the head of a large family and a working mother. She also volunteers with a female Muslim cycling group and is a trained ride leader. During the two weeks of data collection, she recorded 15 journeys, out of which 10 were commuting, 3 were leading organised rides and two were leisure. Thus classifying her mobility would put Amira in the class of utility cyclists. However, this would be a gross misinterpretation. When on the bicycle, this is her time for reflection and independence from daily tasks (motherhood, employment). She stated: "Once I am on the bike, I can turn this way, or that way without telling anyone." In Fig 6 we can see the ecosystem of the routes she takes to and from a regular destination (the exact location has been obscured to preserve privacy). Upon examination, we can see that there are five variations on the route, one of which incorporates a loop through a park. Asked to explain this behaviour, she explained that the route depends on the level of energy and need for contemplation on the day. There is no practical reason for the deviation, such as a visit to a shop on the way or a roadblock and this behaviour would not have been exposed in an interview or a survey.
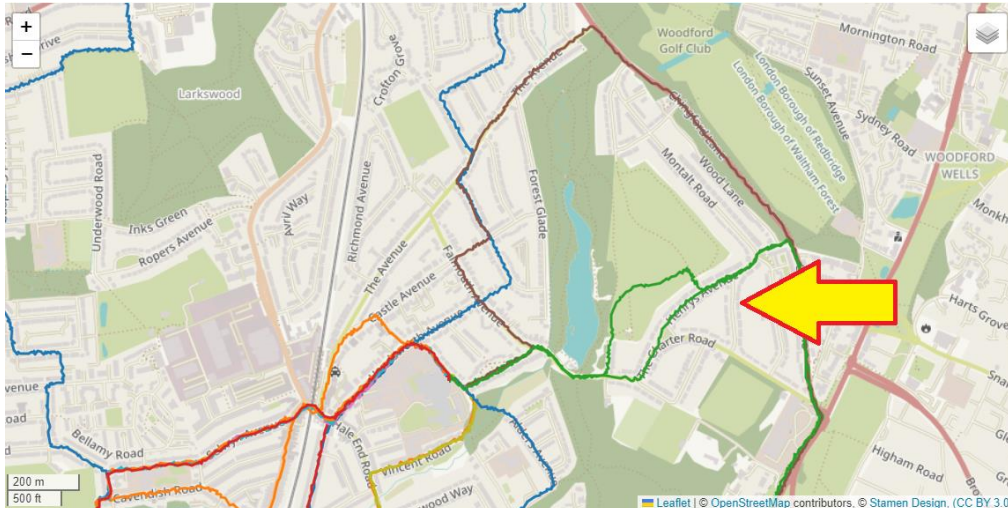
Figure 7: Different routes Amira takes to and from same destination. Yellow arrow is highlighting an instance of incorporating a park visit on the way to work.

She also has an interesting attitude towards cycling infrastructure. For her, long, straight segregated stretches are more tiring than the diverse experiences of dealing with traffic, or using side streets, as she finds safe monotony mentally dulling.

Despite having children, she cycles with them very rarely and does not use the bike for utility tasks or care journeys. Nor does she do any trip-chaining. It is primarily her time for reflection and independence from daily tasks (motherhood, employment).

3.1.2 The Novice Cyclists: Thea

"I always cycle in the company."
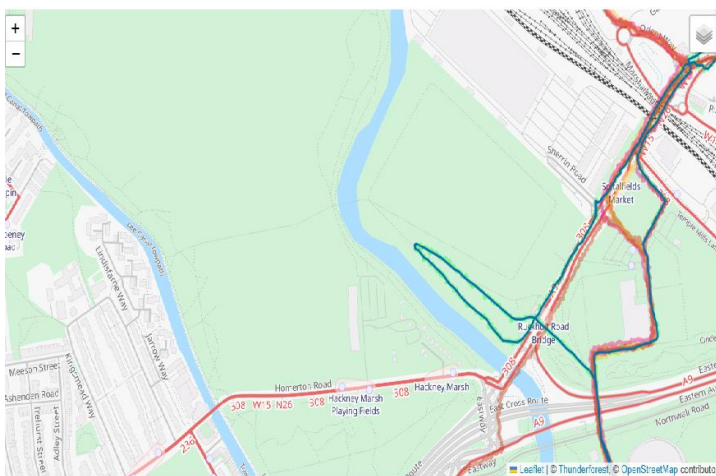
Figure 8: An example of Thea exploring her environment.

Thea is a novice cyclist. She is a single woman in her late forties who learned to ride through a local authority scheme and has built her confidence by taking part in Women Cycling Group's beginner rides. She is at the beginning of her cycling journey and while very enthusiastic, aware of her lack of skill. For that reason, she tends to always cycle in company of others. She recorded rides on five days, with all the rides lasting over two hours. The first interesting pattern visible in her notebook is that all her rides are very early in the morning and mostly on the weekends. Also, there is very little overlap in the routes. The reason for this became evident when she started describing her recorded movements. While one might expect an inexperienced rider to stick to familiar and signposted routes that is not the case with Thea and her friends. Thea uses the cover of early weekends to explore her environment and expose herself to cycling on a variety of provisions in a gradual way. She is fiercely experimental and determined to carve out a place for herself. This has only been made possible by her involvement in the cycling advocacy group as they gave her the initial introduction to the area and this is where she met her cycling friends. Fig 7 shows one of the anomalies in Thea's cycling that is a result of the trial-and-error approach she has adopted in the absence of cyclist-friendly signage in her area. Thea also does not use a bicycle for utility, commuting, or care and does not do trip-chaining when out.

3.2 Analysis of the Cohort's Interaction with the Data Notebook

Due to COVID-19 disruption, sessions meetings took place in public venues and using the researchers' device. Hence, the interviews were performed using a chauffeured interaction method (Wood, Beecham and Dykes, 2014) where participants instructed with prompts and the researchers executed them.

3.3 Observations on Session Interaction

Participants had different levels of activity during the recording period and different levels of engagement with the sessions. The length of the sessions ranged from 25 to 80 min, while the number of journeys ranged between seven and seventeen. In Fig 10 we can see that the high number of recorded journeys does not indicate longer interviews. The two participants who were new to cycling spent the longest discussing their outings, while the participant with the most recorded journeys spent only 3 minutes per route. However, there were some commonalities. The two participants whose interviews were the shortest both performed short, repetitive journeys with little variation.

| Frequency of map use				
	Humanitarian	Cycle	Transport	Neutral
Journey tracking	23	21	21	7
Multichoice	2	3	4	3
Supporting features use				
Speed	Diary		Scatterplot	
40	31		26	

Figure 9: This table is in two sections. The top section contains aggregate numbers for map use by type and by journey choice. We can see that participants preferred to examine single journey and that the humanitarian map was the most used, while neutral was used the least. Of the supporting features, speed tracking was the most used.

Further, only one participant chose Cycle OSM map as their first map as majority commented that it "gives too much detail". However, we can see in the Fig. 9 that six out of seven participants used it throughout the interview despite their initial reluctance. Participant A only used the Humanitarian map as it "looks more familiar". The Humanitarian map was the most frequently overall, as we can see in the table depicted in Fig 9. Neutral map, that contained the least embedding, was also used the least. The most utilised feature was the speed tracking and the least scatterplot as the time frame and the ride frequency were not long enough, and complex enough to require deeper analysis or to hide patterns.
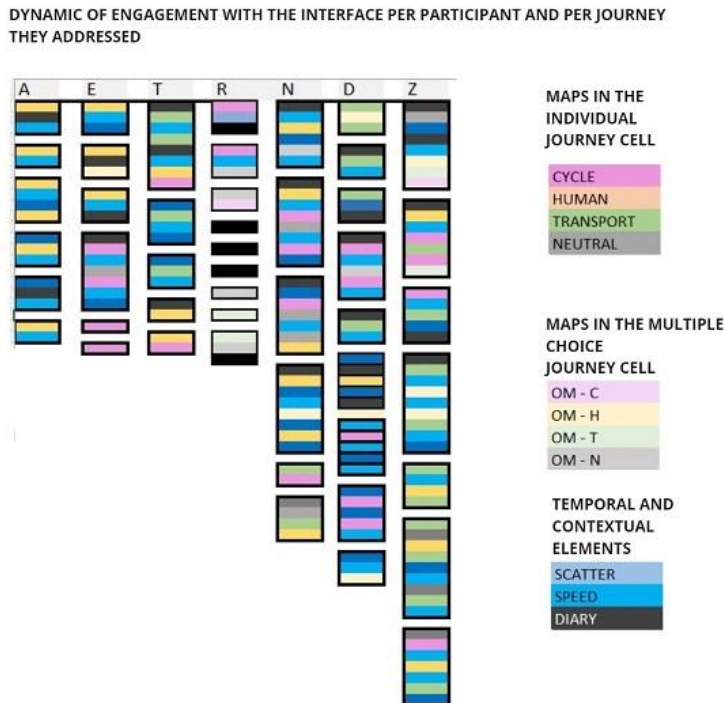
Figure 10: Dynamics of engagement per journey and per participant. Each column is one participant and each block is one journey they discussed. The legend on the right gives us the encodings for the elements of the data notebook.
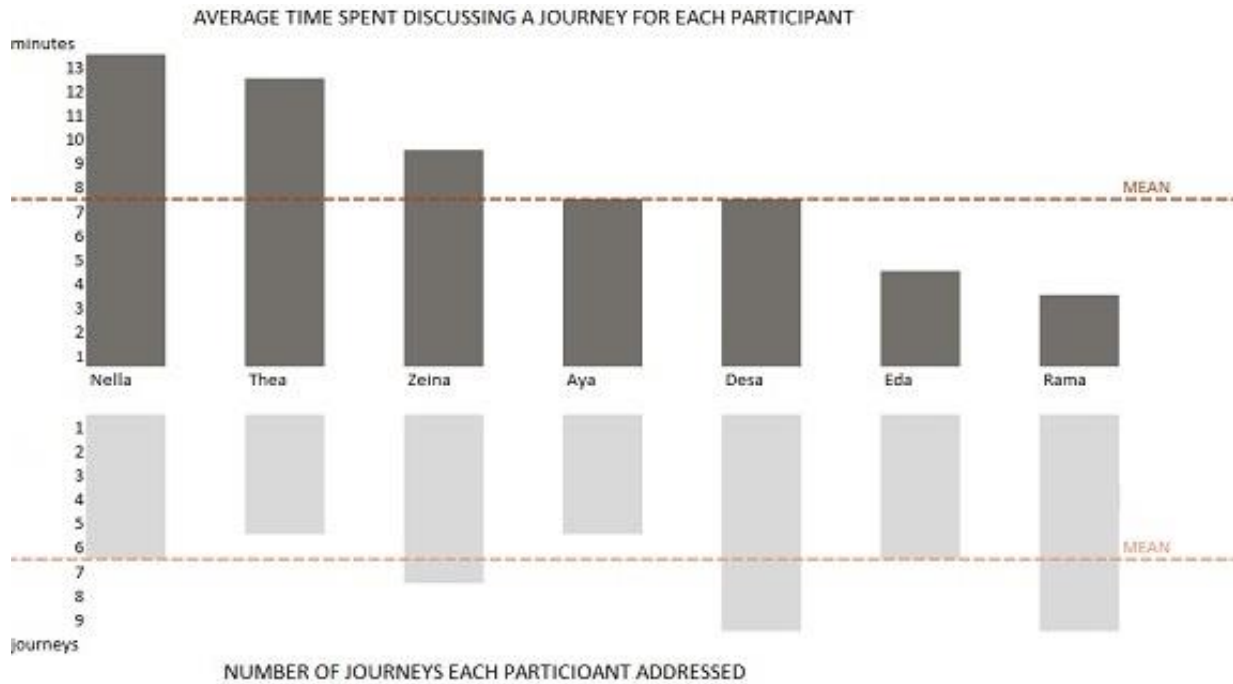
Figure 11: Number of journeys discussed by each participant. The top bar chart shows average time the participant has spent discussing journey, while the bottom bar chart shows the number of journeys the participant recorded. The humanitarian map has had the relevant prompt. (We have used pseudonyms in order to protect the participant's anonymity.)

3.4 Cycling Habits

As we established, the cohort was diverse in cycling proficiency. Despite variations, there were common motivators for cycling among the participants. The frequency of specific journey types was determined based on the count of participants engaging in them. Six out of seven participants engaged in cycling for well-being, which included fitness, recreation, and mental health purposes. Examples included extending cycling time or making detours for solitude and respite. Only one participant primarily focused on care journeys and did not make any well-being rides. Five out of seven participants engaged in social bonding journeys, either with organized groups or with friends and family. Three participants participated in community engagement activities, which sometimes overlapped with social bonding. Utility, commuting, and care journeys were less frequent, (Fig 11).

Activity	Total
Well-being	6
Social bonding	5
Community engagement	3
Utility	2
Commute	2
Care	2

Figure 12: This table shows which type of cycling the participants engaged in. All, bar one participants cycled for well-being and only two used bicycles for utility, care or commuting.

The interviews conducted for thematic analysis revealed additional themes (Fig. 12) that were not directly related to motivations and cycling purposes. These themes were expressed by specific subgroups within the cohort, aligning with the cycling competency classification. The most frequent overarching themes identified were independence, well-being, social bonding, fear of attack at certain stretches, and a preference for circular routes.

Universal Themes	Total
Independence	6
Documenting rides	6
Safety from attack	5
Preference for circular route	5
Flexibility	4
Preference for early mornings	4
The preference for side roads	2

Figure 13: A table of general themes identified using thematic analysis.

However, there were specific themes that emerged only in interviews with intermediate and beginner riders. The most common theme among them was the impact of organized rides. Some participants had recently benefited from such rides, while others were actively searching for them as there were none available in their area. For example, Rama cycles the route they were introduced to by the group member on a single occasion and she repeats the same route every morning but she has no confidence to expand on it by herself while Thea cycles either with the group or with friends she has met on the group's rides.

Another strategy observed among beginner and non-confident cyclists is non-peak-time cycling. During quiet periods like early mornings and weekends, they take the opportunity to familiarize themselves with the environment or simply enjoy cycling. Exploration is also common, where cyclists engage in trial and error to find preferred routes. Lack of signage remains a common issue for all cyclists, especially for those new to London or new to cycling in the city. Counterintuitively, less experienced cyclists in this study tended to cycle longer routes compared to more experienced ones, regardless of time constraints.

Intermediate and Beginner Themes	Total
The effect of organized rides	4
Non-peak time cycling	3
Exploration	3
Longer safer	2
Cycling expertise	2

Figure 14: A table of themes specific to intermediate and beginner cyclists.
They acknowledge the importance of having a supporting infrastructure. They use exploration and cycling in non-peak times to acclimatize to the environment. They use exploration to re-learn their environment and will go a longer route if they consider it safer.
There is also a need to acquire cycling expertise

Lastly, the theme of cycling expertise emerged, encompassing knowledge about safe routes, suitable bicycles, cycle purchasing schemes, and reliable repair places with good bike locks. This knowledge can be transformative for new cyclists, Clara remarked that buying a good lock has opened up new possibilities for her.

4 Discussion

The most surprising finding of the study was that only one participant used the bicycle for care journey or trip-chaining. The motivation for cycling does not appear to be care of others but self-care and cycling for well-being (Ravensbergen, Buliung and Sersli, 2020; Sersli *et al.*, 2020). Only one participant, who is a mother to a young family, did not explicitly prioritize well-being trips, which aligns with the challenges faced by young mothers in engaging in self-care activities (Ravensbergen, Buliung and Sersli, 2020; Sersli *et al.*, 2020). Nevertheless, this participant highlighted the increased independence and mobility that cycling provided, which positively impacted her well-being (Glackin and Beale, 2018).

A prominent theme observed among the participants was the fear of attack in parks and secluded areas, which is not extensively discussed in Western research. However, a study in Solo, Indonesia, found that violence against women cyclists is a major barrier to cycling for the majority of women (Song, Kirschen and Taylor, 2019). The lack of available data on attacks against cyclists in the UK further underscores the marginalization and power imbalance faced by cyclists (Pucher, 2001; Horton, 2006; Chen *et al.*, 2012; Schepers *et al.*, 2014; Adams, 2015; Pedroso *et al.*, 2016). This further illustrates the lack of inclusion of the female perspective when planning and developing cycling infrastructure in London as a great proportion of the dedicated cycle paths run through paths and on the towpaths which are dark and deserted after dark (which is 4.00 pm in winter). The findings also have implications on the city and cycling provision layout beyond safety concerns as the urban structure is poorly suited for social cycling, cycling for introspection, and especially for novice riders. If we are to bridge the gap between men and women cycling, we need to modify cities in a way that would enable more women to learn to cycle and immerse themselves in an environment that, at the moment, is hostile to beginners.

Another identified theme is the preference for round journeys, where participants choose different routes for their return trips. These preferences and safety concerns can influence inclusive city planning efforts (Lam, 2022). The seasonality of cycling experiences, both in terms of time of day and year is also not accounted for in urban planning but is a major mobility factor.

Cycling advocacy groups were found to play a crucial role in normalizing cycling, providing support and knowledge for individuals at different stages of cycling proficiency (Maskell *et al.*, 2018). This seems to be true for women cyclists of varied abilities as the groups share skills, train, and provide positive modelling and social scaffolding necessary for continual engagement with cycling.

The evaluation of the interface used in the study, which aimed to elicit insights and narratives, presented challenges in quantitative measurement. While the diary was consulted multiple times, its effectiveness varied. On the other hand, the speed-tracking aspect of the interface provided useful information and helped identify key areas of discussion. Combining movement with environmental representation proved to be an effective method for engaging participants and stimulating recollection, aligning with the link between motion, abstraction, and memory (Tversky, 2019).

The study has shown that mobility capture, visualization, and discussion rooted in the person's mobility reality are effective ways of gathering new insights and discovering new avenues of research. While it might be challenging to run the study on a large scale, it is an effective way of exposing new avenues for exploration and new themes.

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