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Map Augmentation and Sketching for Cycling Experience Elicitation

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Abstract

This work examines the use of maps for knowledge elicitation in the sphere of urban cycling. The study involved running 14 distinct workshops, each serving as a unique data collection session for a particular individual. In each workshop, the participant was provided with 12 different renditions of the geographical areas as well as drawing materials. The geographical area renditions contained regions specified by the participant as cycling locations during the preparatory correspondence. The outputs were analysed for patterns in map augmentations and thematic content in the sketches. We have found that participants engaged deeply with the map augmentation process expressing their preferences and giving new insights. Themes such as connectivity, scenic beauty, and temporality emerged prominently from the analysed data, shedding light on the subjective experiences and preferences of urban cyclists.

CCS Concepts

• ***Human-centered computing*** → ***Empirical studies in interaction design; Empirical studies in visualization; Geographic visualization;***

1. Introduction

Our mobility significantly shapes our environment, as evidenced by the denser, walkability-influenced urban design of European cities compared to the more dispersed, automobile-centric American cities; this underscores the importance of understanding and visualising the cycling experience to enhance active travel [CCB*16]. This paper details workshops that utilised interactive, personalised tasks and diverse mapping tools to delve into individual cycling experiences, revealing socio-spatial relationships and informing sustainable transportation development.

The research question we tried to answer is: **How can data visualisation, incorporating visual stimuli and qualitative methods, enhance the contextual exploration and externalisation of the cycling experience within active travel?**

In geography, there is a difference between space, which is measurable, and place, which is "elaborated by cultural meanings people invest in or attach to a specific site or locale" [III18]. Where does this leave the people who cycle, and their connection to, and experience of (sometimes very fleeting), spaces they travel over and places they travel through? Travelling by bicycle transects, dissects, brushes, and skims recognised spaces and places. Cycling can be confined within one spatial region, such as a local neighbourhood, often, it is not. Cyclist usually passes through municipalities, districts, and neighbourhoods. Sometimes it follows the shortest, sometimes the least hilly, and occasionally it stays on the designated path. Thus, in a sprawling urban environment, such as London, people who cycle, and their experiences are difficult to capture and measure, and what we often get is fractured and incomplete. Thus, maps can be used as a surrogate for real journeys that transcend and allow examination with fewer spatial boundaries. However, maps encode and have their own expression and representation of the world they reproduce. we aimed to explore the possibilities and constraints of maps as a surrogate for the exploration of the cycling experience.

In this paper, we describe workshops focused on the individual using interactive and personalised tasks. Each two-hour session was designed to enable participants freedom to fully expose their own view and allow them to to self-pace. Materials such as white and coloured paper, maps, and drawing tools were arranged to encourage unbiased choice between sketching and map augmentation. The setup minimised predispositions, ensuring a mix of materials within easy reach. Participants engaged with a variety of maps, including Google Maps, OpenStreetMaps, and custom QGIS maps, which facilitated the observation of their preferences and choices. Using these resources, they articulated their thoughts on cycling and explored both spatial and emotional connections.

Outputs, including sketches and annotated maps, were discussed in semi-structured interviews where participants explained their work, focusing on the outputs that resonated most. This narration

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enriched the data and provided deeper insights into their cycling experiences.

The collected data, including maps and drawings created by participants, was rigorously analyzed using thematic analysis [BC13b]. This analytical approach was employed to delve deeper into how participants perceive and interpret their cycling environments. The goal was to uncover underlying themes that reveal the participants' experiences and emotional connections to the spaces they navigate, emphasizing how they use various mapping and artistic materials to express these relationships. This method facilitated a comprehensive understanding of the personal and spatial dynamics influencing cycling behaviours.

The study explores the significance of visual and narrative methods in capturing socio-spatial relationships with environments. Findings suggest these methods provide comprehensive insights into personal experiences, which is crucial for developing better cycling infrastructure and promoting sustainable transportation.

2. Related Work

The growing enthusiasm for active travel and cycling has prompted a broad spectrum of research across various disciplines. We examine the role of data visualisation in enhancing understanding of cycling behaviour through various mapping techniques and origin-destination data analysis, exploring the emotional connections cyclists form with their environments, and discuss innovative visual and participatory methods such as sketching and counter-mapping to capture and convey the multifaceted cycling experience.

The heightened awareness of active travel benefits has led to a thirteen-fold increase in cycling-related academic publications between 1995 and 2016, covering a comprehensive range of topics and perspectives [PB17]. These vary from analysis of the infrastructure provision [MTLK18], and diversity in cycling [AD17], to how cycling is represented in the media [Cai20]. Our work sits at the intersection of disciplines. We will touch on the main streams and influences such as data visualisation and active travel, mapping and qualitative data, the use of sketching and augmentation and lastly personal data visualisation and counter-mapping.

2.1. Data Visualisation and Active Travel

The emergence of public bicycle hire schemes, such as London Santander Cycles, has proved beneficial for furthering the understanding of cycling behaviour as it provides researchers with previously unavailable data regarding the origins and destinations of trips. The potential and properties of visual investigation of **origin-destination** (OD) data have been critically examined and explored Wood [WSD] and Adrienko et al. [AAFW17]. Adrienkos' research employs diagram maps for spatial and temporal abstraction, effectively presenting insights from data with geographical and chronological dimensions. Wood employs flow maps, girded views, and OD maps to reveal various aspects of the dataset. Simultaneously, Zhou [ZMT*19] enhances the visualisation of origin-destination data through an iterative multi-objective sampling scheme and meaningful visual encodings, supported by a system that minimises clutter and emphasises correlations. OD data can be the basis for faceted migration analysis. Two examples are Wood and Beecham's examination of commuting behaviours [BWB12] and the investigation of gender balance in the user population [BW14]. Those works attempt to look at the mobility trends and tie them to other, socio-economic data dimensions. However, any examination of OD data does not reveal the rider's friction and ride experience as the chosen route itself is unknown. The algorithmic predictions, which model the optimal path based on distance and available cycling infrastructure, do not successfully mimic users' behaviour. We argue that such quantitative paradigms lack subtlety and richness which are important in forming human experience.
Another valuable data source is passive activity trackers like Strava service. Strava records its users' movements which contains the route. McArthur uses the Strava dataset [MH19] for identification of the cyclists' deviation from the shortest path, which is performed to lay ground for investigating user choice. An example of visual analysis of an active travel environment is mapping the infrastructure according to a pre-agreed classification. A work by Mineta Transport Institute [Min98] classifies the **cycling experience** according to the level of stress cyclists experience and relates this to user groups. This is the basis for some practical and interactive visualisations, such as Montgomery County Bicycle Stress Map. Works like these are aimed at city planners, enabling an **analysis of accessible cycling network** distribution and used by the public as a **navigational and planning tool**. The creation of such maps relies on in-depth, city-wide data that is often difficult to obtain for larger metropolitan areas, or even in some small settings which do not prioritise transport and infrastructure development. The data can also prove difficult to maintain and keep up to date. The **reported incidents data** is easier to collect and maintain. Maps produced by cycling advocacy organisations, such as CycleStreets, regularly include such historical records as one of the optional layers.

2.2. Mapping and Capturing Experience

The idea of mapping abstract concepts is not new. An example is Mapping the Invisible City [CDK*15] by Leicester University, which explored the **emotional connection** young people have to their environment. A recent project by Loukissas called Map Room [LN21] takes this one step further by creating an immersive and interactive space with map projections as a media to invite communication and expression in an open and immersive setting. Their work explores what data means in terms of community engagement as well as allowing exploration of the spaces and their meaning in a new, active and creative way. A technique known as **deep mapping** has emerged as a profound and insightful approach to exploring places and the intricate traces left behind by both past and present individuals. A good example is Taylor's [Tay16] examination of a single cycle journey through London's East End while collecting personal metrics and diarising the experience. The resulting work looks at the meaning of data, the meaning of a place in its historical and present setting, and the person's journey through it.

2.2.1. Sketching and Augmentation

Sketching has been shown to [KH04] enable representation of user emotional experience and help participants express attitudes towards their environment [MFK19]. The Bumpkin Island mapping

initiative [DHH18] combined participatory sketching with contemporary art to facilitate expression and discovery. Hinrick's work firmly exposes the importance of qualitative methods contribution [HFM19] and pioneers collaboration between visualisation and humanities [HEAB*].

Sketch maps have been used to examine the relationships people have with their cities and Brennan [BH10] used sketching to identify hot spots and high-traffic areas that are of importance to the creative community.

In his seminal work [Lyn60] Lynch uses sketches and mental maps to explore how citizens 'see' their cities and creates his own categorisations of the elements. Marquart et.al [MSU20] utilise sketch maps to examine perceptions of the cycling infrastructure quality. Buxton's work [Bux07] explores sketching for design development and his collaboration with the Data Experience Laboratory of the University of Calgary [GCMB12] is a comprehensive guide to sketching methods and participatory sketching.

2.2.2. Personal Data Visualisation and Counter-mapping

Data visualisation is an analytical tool but also a vehicle for personal reflection and exploration. The examples are the personal-diary correspondence of Giorgia Lupy and Stephanie Posavec, as well as Perin's work [Per17] where he records and presents a year of activities in a way that allows the reader to see the interplay of different demands on his life and progress. **Radical cartography** is an approach to mapping, of which counter-mapping is a branch, that challenges the traditional themes and dominant narratives, often by focusing on underrepresented and marginal communities [Sch21]. In the context of mobility and cycling, radical cartography has been used to present and highlight the hazards of urban cycling. An example of this is the recently published interactive "Map of Dangerous Junctions" [Hil24] that presents the last five years of data on emergency responses to incidents involving cyclists and pedestrians. The map integrates visualisation which relates the frequency and severity of incidents overlaid on a traditional map. On the other hand, a bicycle workshop with black youth in the US presents counter-mapping as an exploration from within. It is a process of development; both of cycling ability and visual literacy which ultimately enables both spatial exploration and personal expression [TH13]. Our projects utilized a bottom-up approach, using the visual representation of routes as a vehicle for eliciting meaningful reflection and insight into the reality of cycling. This approach helped to uncover causes of friction, as well as mitigators and compensators that assisted cyclists in overcoming these challenges.

3. Methodology

The study explored individual cycling experiences through individual workshops where participants expressed their cycling-related concerns using diverse maps and drawing materials without written instructions, aiming to foster creativity and extract themes in how non-experts visually interact with personalised geographic representations. Recruitment focused on a diverse group of 14 cyclists, highlighting both the detailed participant demographics and the variety of maps used to engage with and map their cycling journeys effectively. The recruitment of the participants was conducted by way of convenience sampling [BC13a] at the home research institution. The outputs were analysed by way of thematic analysis [BC13a].

In the workshops, participants were encouraged to convey their cycling-related concerns using the provided materials without specific instructions on the aspects to explore or the sequence for using the materials. The sole requirement was to refrain from writing. The aim of the study was to:

- Study the impact materials and the process have in supporting participants' creativity and expression.
- Extract emerging themes in spoken and visual expression.
- Explore how non-experts visually interact with maps.

3.1. Recruitment

The recruitment was done by means of advertising over internal social networks and by leafleting and postering. Qualitative studies, due to the depth of the analysis, do not require large numbers [BC13a] and we recruited 16 participants, out of which 14 completed sessions. Table 1 shows the gender, occupation and cycling in UK distribution for the cohort which was mostly balanced.

Participant Statistics			
Years cycled/UK	1<10	10<20	20<
	8	1	5
Occupation	Support staff	Student	Academic staff
	6	5	3
Gender	Female	Male	Non-binary
	8	5	1

Table 1: *Table showing the length of UK cycling experience, occupation bracket, and gender distribution for the 14 participants.*

One of the recruiting goals was to provide a diverse sample and reach cyclists who tend to be underrepresented in the data collected by passive means and when working with advocacy groups [Lam18]. This goal was met in terms of gender diversity, but not in terms of ethnicity or socio-economic status, as 90% of the participants were white and employed in white-collar professions.

3.2. Individual workshops

The participants were given a range of colouring and drawing materials. The table was covered with a selection of maps interspersed with pieces of blank, white, and coloured paper. Care was taken with the layout, so that no section of the table contained only one type of resource.

3.3. Maps

For each individual, we have produced 12 types of maps. Starting with standard maps like Open Cycle Map and Google maps, progressing to custom maps made using QGis software. The maps varied in level of detail and features included. This ranged from cluttered Open Cycle Maps to the very basic rendering of road grids. When producing the custom maps we avoided inserting landmarks

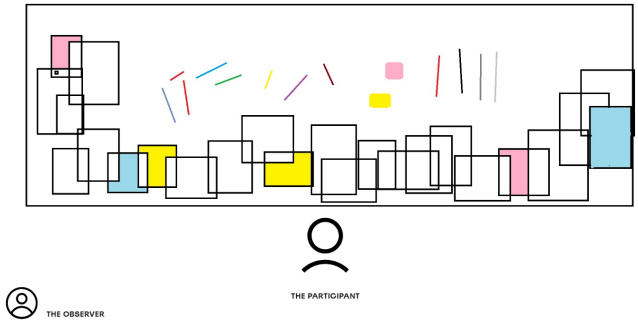


Figure 1: *The table layout. The paper and one example of each type of map were within easy reach for the participants from the position in the middle of the table.*

such as buildings of importance as they were present in the OSM and Google maps. The examples of the maps can be seen in the Table 2.

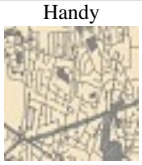
Google - Basic 	QGIS With Buildings 	QGIS - Road Names 
Google - Satellite 	QGIS - Natural Features 	Handy 
OSM - Cycling 	Transport Dark 	OSM - Landscape 
OSM - Transport 	QGIS - Just Roads 	OSM - Outdoor 

Table 2: *Examples of maps used in the study. Standard maps are rich with features which are specific to the use while custom maps have less noise and detail.*

When preparing the maps, we wanted to give participants a wide choice of options. we narrowed down the basic specifications for maps to these:

- The selection of maps needed to include both familiar maps (like Google Maps and OpenStreetMaps) and less familiar maps to assess participants' preferences and openness to different maps [NP20].
- Maps aimed at the cycling community were included because they contain specialised features such as cycle paths and repair shop locations.
- To encourage participants to sketch, some maps were rendered with a white background to resemble a canvas and make drawings more visible.
- Each map was represented at a different scale to allow participants to explore their journeys at varying levels, from entire routes to detailed neighbourhood sections.

We asked participants to engage with both maps and sketching but did not dictate the order. The prompt for both types of engagement was to ensure consistency in the analysis and establish how much these two ways of expression differ or correlate in their outputs.

4. Analysis

Participants in the study produced multiple augmented maps primarily focused on commuting, with some addressing leisure and retail journeys, revealing preferences for feature-rich maps over simpler designs, and demonstrating significant engagement through the consistent marking of similar routes across different maps, which they used to express diverse aspects of their cycling experiences.

4.1. Analysis of Augmented Maps - Engagement

The maps used in the study were divided into two sub-groups; the 'traditional' maps which included man-made landmarks such as railway lines, supermarkets, hospitality places, etc. (depending on the map), and the maps we created where there were no such landmarks. By dividing them in this way, We wanted to see if the participants had a preference between feature-rich maps and maps that convey only basic information but leave more space for customisation. **All the participants used a variety of maps** but we found that **participants prefer feature-rich maps**. The most used maps are Google, Cycle map, and the custom map containing roads, houses, green spaces, water, and street names (RGWN). No participant opted for using only ready-maps, or only custom-made maps. Looking at the overall number of maps used, by map type, Google maps were used most often (15), followed by Cycle maps and custom maps containing road names, green spaces and water features. The least used maps were the maps with no road names and no green spaces and Satellite maps. When asked about the reasons behind the map choice, participants said that ready-made maps look the way maps should, implying the participants find culturally embedded practices helpful bridges for translating their actions into two-dimensional space. For the particular choice of custom maps, the reason cited was the clarity and accessibility of street names.

Exposing participants to a variety of maps, most of which were not created with cycling in mind, has resulted in some surprising results. For instance, the dark transport map prompted Participant Ten to reflect on the seasonal challenges of cycling, which they then incorporated into the five sketches created after interacting with the maps. The bus numbers on the OSM Transport Map inspired Participant Five to reflect on the possibility that a map with cycling times would be helpful for people new to the city.

(a) *The commute depicted on the OSM Dark Transport map.*

(b) *The same commute on the OSM Daytime Transport map.*

Figure 2: *An example of **map-riding** as the participant has produced several representations of the same route without embellishments. The same participant has produced several sketches following their engagement with maps.*

Five out of fourteen participants did only minimal augmentations and either only marked routes or circled already present features, while two participants produced both richly augmented maps and a number of less-augmented ones. Further analysis showed that four participants consistently marked the same route across multiple maps. We can see an example of this behaviour in Figure 2 as the participant has drawn the same route on two very distinct maps. In actuality, this participant repeated the route on four maps. Each map would be a recollection of the journey under different conditions. **This behaviour, which we call map-riding shows that engagement with the maps and the type of map is important, in that map content and layout stimulate participants to consider aspects of cycling that they might not have otherwise. In this example, riding the same route in different seasons.** Participants four, ten, twelve, and fourteen all engaged in map-riding and used thus gathered insights to produce sketches which were content-rich.

Another observed type of behaviour is **feature latching (FL)**. Feature latching is when a participant does not look beyond what is already present on the map. Examples of feature latching include maps where the participant has only circled icons or place names, as well as their output being double-encoding the existing features, such as drawing trees on the park.

FL suggests that map-based research can be shaped significantly by the careful selection of representations, as people may limit their responses to what is depicted on the map. Feature presentation can be unintentional, leading to unexpected participant engagement. For instance, on a basic monochrome map of roads, one participant specifically noted a roundabout. In the interview, they commented that they found the map confusing and that this made them mark the roundabout as they found roundabouts confusing. That particular roundabout was present on the quarter of the maps available to the participant, and a number of the maps that the participant used. However, the confusing effect of negotiating the complex roundabout has been marked only once and was brought to the participant's attention not by its presence, but by their observation of the map's accessibility.

4.2. Analysis of the Augmented Maps - Augmentations

Just as in their behaviour when choosing maps, the participants exhibited patterns in the treatment of visual channels.

Expressiveness This section examines the marks that cannot be categorised as icons or a symbol. As per Cleveland and McGill, graphical perception is achieved by; the detection of geometry; assembly which helps us discover overall patterns in data; and estimation, by which we can assess a relative value [CM84]. Hence, we are categorising expressiveness in two ways: by type of element and the role played in what the participants were communicating.

By type of element, the expression can be divided into **Simple Lines**, which are used to circle features or areas and can be circular, angular, or irregular in shape and **Texture**, exemplified by wavy, dashed, and enhanced lines, as well as textures added to an area. They were used to communicate:

- **Hierarchy** - Hierarchy indicates preferences or quality, such as a favoured route or better roads, allowing items to be ranked..
- **Classification** - Classification reflects emotions or experience complexity, grouping items without a specific order. For instance, if participants love one location and hate another, these are distinct categories that cannot be ranked.
- **Emphasis** - Is also an ordinal value and it communicates a level of importance.

An example of *hierarchy* is marking primary and secondary routes with solid lines for main routes and dashed lines for optional paths. *Simple lines* are frequently used to delimit areas, icons, and words, providing emphasis without detailed representation, and for signposting.

The texture is used for classification, with bold lines marking straightforward routes and wavy lines highlighting routes influenced by various factors and emphasizing the environment. It can also convey emotions; for example, irregular patterns with sharp angles suggest a strong dislike for an area. Variations in texture can prioritize routes and simplify markings in adjacent areas, applying Gestalt principles of similarity and continuity. Participants primarily used lines to mark areas rather than for emphasis, likely because marking areas without boundaries highlights their experiences over the map's content.

The use of Symbols. In their outputs, participants both produced

symbols and responded to the symbols that maps contained. All of the participants used symbols to a certain degree. The most widely used were pictorial depictions, where participants drew sketches of the items and concepts they wished to represent. Participant Two wished to communicate concepts (wind and memory) that are not traditionally mapped and developed their own icons. While memory and wind are not considered spatial concepts, they are often closely bound to the geographies cyclists pass through. Thirteen participants augmented maps by drawing over the mapped areas, but for Participant Three, this was not suitable as they cycle only competitively or using a stationary bike. Despite this, they explored maps and situated themselves by finding their home and workplace. They used map margins to embellish the maps with pictorials of their connection to and attitude towards cycling. The same expression style was continued in their drawing, which comprised several cartoon icons. Participant Fourteen used arrows to great effect. They modified the arrow representing uphill to a series of arches depicting the effort required for every revolution of the pedals during an uphill climb. In contrast, they kept the shaft of the arrow pointing downhill straight. Participants achieved the desired effect when using symbols in the following ways: Participants combined symbols drawing them closely together to communicate complex themes and applied the principle of assembly [CM84].

The Use of colour Seven out of thirteen participants used colour with purpose. This means that they either consistently used the colours to represent the same features on multiple maps, or they used the colour for emphasis. The latter was more frequent as only three participants did not vary their colour assignment (P6, p9, and P14). When asked about the colour assignment, the rest of the participants said that the choice was either random or depending on which pen was closest to hand.

Colour was used to illustrate feature duality, resulting in **conflicting encoding** when a single feature has both positive and negative aspects in different contexts. For instance, Richmond Park can be pleasant or dangerous depending on the time and day. Similarly, a stretch of road might be marked in red to indicate positive, fast downhill and in blue to denote negative, dangerous conditions. **While some participants used colour with intention, the most common behaviour was to punctuate theme change with a random colour change.** Further work, exploring this particular aspect could help ascertain to which degree was the colour choice truly random or if there is an underlying association.

4.3. Analysis of Sketches

All the participants were asked to sketch on blank paper, whether they engaged with the maps or not as we wanted to give them a chance to express aspects of cycling that are not spatially constrained. We analysed the sketches regarding how they related to the maps and what themes the participants chose to present. We looked at whether the concepts depicted in the sketches differed from the ones depicted on the maps; whether there is more content in the maps or sketches, and whether the participant described the infrastructure.

When looking at the map augmentation and sketch content, there appears a correlation. *Participants who engaged with the maps less, tended to sketch infrastructure.* They were also more likely to repeat the content between the two outputs.

As well as content, there was a clear difference in how the participants presented their ideas. These fall into three categories.

- **Depicting Positive vs Negative** - Participants reflected on both positive and negative aspects of cycling.
- **A Montage of Scenes** - The collection of scenes without clear distinctions between pros and cons. Rare negative depictions, such as Participant Eleven's drawing of rain and Participant Ten's depiction of seasonal changes on a towpath, are not arranged to emphasise differences. Participant Seven's scenes highlight issues faced by non-cyclists, which are resolved through cycling.
- **Imaginary Cycling Environment** - The most common type of sketch, with six outputs. It can be divided into *ideal environment* and *summary*. The ideal environment depicts an optimal route with features like good company, weather, gadgets, signage, and repair stations. The summary sketches focus on infrastructure, either showcasing an example route or highlighting problematic areas with proposed solutions.

5. Analysis of Text and Themes

Frequency by Mention

Physical Infrastructure		Journey Execution		Experiential	
Unsuitable Infrastructu	22	Longer nicer	10	Nature	20
Needs signs	17	Temporal/seasonal	13	Joy	11
Cycle furniture	11	Traffic	6	Pedestrian clash	11
Good infrastructure	9	Shortcuts	5	Freedom	7
Junctions	9			Unpleasant infra	7
Traffic lights	9			Cyclists clash	6
Shops	8			Beauty	6
Repair stations	8			Safety	6
Lack of links	6			Sounds	6
				Alert	5
				Convinient	5

Frequency by Participant

Physical Infrastructure		Journey Execution		Experiential	
Unsuitable Infra	10	Temporal/seasonal	11	Nature	9
Needs signs	9	Longer nicer	6	Unpleasant infra	6
Repair stops	7	Shortcuts	5	Pedestrians clash	6
Traffic lights	6	Residential streets	3	Beauty	5
Good infrastructure	6			Joy	5
Junctions	6			Independence	4
Shops	6			Sounds	4
Lack of links	5			Freedom	4
Busses	5			Traffic	4
Cycle furniture	5			Alert	3
Lacks infrastructure	4			Cyclist clash	3
				Convivient	3

Figure 3: *The above two tables depict the most frequent themes from the interviews. The themes are divided into three classes depending on whether they are related to the physical infrastructure, the way participant travels, or how they experience their journey and its environment. The top table is ordered by the number of times a theme was mentioned, while the bottom one is by the number of contributors that mentioned it.*

Thirteen out of fourteen participants interacted with and enhanced the maps by adding and accentuating features. They directly

marked themes such as green spaces, cycling infrastructure, potholes, and even memories and wind conditions on the maps. However, despite eight participants closely studying the maps, their visual expressions lacked richness, prompting us to use interviews to delve into the associations and thoughts the maps provoked. The initial theme identification occurred during the transcription of recordings, which were then transferred to NVivo software for further analysis. The resulting themes were divided into three classes: themes that relate to the physical infrastructure, themes that relate to how participants choose to travel, and lastly, themes that relate to their experience of cycling and the cycling environment Figure 3.

As can be seen in the section 5 two tables, the main themes participants discussed were *unsuitable infrastructure, remarks on nature in their surroundings, need for more signage, taking longer but more pleasant routes, seasonality of the routes and the joy they experience when cycling.* Participant Eleven observed that unsuitable cycling infrastructure can be a deterrent for new cyclists and that cycle maps have a role in spreading misinformation, in that they inform people where it is suitable to cycle falsely.

The presence of natural elements like trees (P9), the beauty of the surroundings (5 participants remarked on it), and even the sounds they hear (P6), appear to have a great impact on their experience and enjoyment of cycling.

Another frequent theme was the need for better signage. Nine participants remarked that routes could be improved by the inclusion of signs for better orientation, for finding facilities, and for route planning.

When it comes to the act of cycling, the second most mentioned theme was the temporal and seasonal aspect of cycling (mentioned by 11 participants). Here, the most discussed was the difference between summer daylight hours and winter hours but also the changes that depend on the time of day or weekday/weekend difference in the use of spaces (nurse on shift work).

Something that did not make it to the list of most frequent themes, but was mentioned, was the mental health benefits of cycling. The inclusion of it in the analysis is not based on the number of participants that addressed it explicitly (2), or the number of references (4) but on the strength of the language participants used when discussing it. For example, one of the participants remarked: *"...I do find a lot of things quite stressful about living in London, and for me, it is a real relief to be able to move and function in London. But for my bike, I wouldn't be able to. I don't think I would be at all well, otherwise"*

6. Discussion and Conclusion

This was an exploratory study collecting outputs from fourteen individual sessions in the form of augmented maps, sketches, and recorded interviews. The analysis was an iterative process of cross-referencing and code refining. The study looked at the research questions:

1. *To what extent can visual stimuli, combined with quantitative and qualitative methods, contextualise and externalise the cycling experience?*
2. *How can data visualisation support contextual exploration and qualitative expression of active travel?*
3. *What is the relationship between visual stimuli and responses and do the types of stimuli predispose certain types of response?*

We have found that maps are effective in eliciting recollection and engaging people who cycle in reflection of their experience. Thirteen out of fourteen participants, given the choice, engaged with the maps instead of opting for other provided materials (blank paper and drawing tools) and modified the maps themselves. People engaged with a wide variety of maps and no pattern or preference could be detected at this level of analysis. When questioned as to motivation; preference was given for maps with clear names and roads displayed, such as Google, OSM Cycle and Rods, Green areas, Water, Names, and Buildings custom map. In some cases, it was explicit that the map type inspired a thinking avenue. Participant Ten stated that the OSM Dark Transport map reminded them of cycling in winter when it gets dark, and Participant Five reflected on the usefulness of knowing the time it takes to cycle a section of a route based on a map feature (numbers that denoted buses travelling the roads and which were positioned as a label). Further, seven participants discussed bike shops and the need for repair stops, and this was one of the six most frequent themes. It was also a feature in the OSM Cycle map.

The features the participants engaged with the most were the roads themselves (twelve participants mapped a journey). Some icons that were present in maps were referenced and noted in sketches (pint glass, repair shop sign). The five participants who creatively engaged with the maps used icons, pictorials, and marks, as well as created their own symbols to express cycling-related features and experiences.

Looking at the way participants expressed themselves, eight out of thirteen people (60%) made simple augmentations and expressed a lack of drawing confidence. Participants used visual metaphors for conveying cycling-specific situations such as using a wavy line for leisurely journeys in contrast to the straight line of the commute.

Regarding the use of colour in their expression. When asked, ten participants claimed that the colours they used were random or a matter of chance and the use was not with meaning. However, the majority of participants did vary colours they used, if not on the same map, then in different renderings. From observing their work in the context of their narrative, it appears that changing the colour meant a change of theme and signalled a new subject in their output. This behaviour seems subconscious and automatic. The implication for further research involving sketching outputs is to be cautious when interpreting colour assignments as what looks purposeful classification might be a symptom of the thinking process. Further, the participants who started off with a system abandoned it as the number of encodings increased. This might be related to the way we perceive numbers and objects. Particularly, to the phenomenon called **subitising** which is a finding that the human brain can automatically process, recognise and automatically mathematically manipulate small numbers (from 0 to 4). Subitizing is recognised and taken into consideration when it comes to mathematical education but we could not find literature on its effects when it

comes to organising self-expression in sketches and personal data visualisations.

The analysis of the sketches and comparison with the maps have shown a relationship between the level of engagement with maps and the type of output. Participants with simpler augmentations produced sketches containing more infrastructure. Without further analysis, it is difficult to speculate as to the cause. It may lie in the contributor's attitude towards cycling and the cycling environment, but there is the possibility that the content of the maps did not engage the participants in a way that would elicit deeper reflection.

When it comes to the type of journeys participants choose to represent, their commute to work/study dominated. This might be because the study was conducted at their place of employment/study. Only two out of nine female participants included non-employment-related journeys despite the availability of maps at a higher scale, which we presumed would be suitable for an in-depth examination of local areas and to support the exploration of non-employment-related daily migration. Despite the research which has found that women, more than men, engage in trip-chaining [SW14] and do more local travel, [SLM00] women in the study used their bikes mostly for the commute.

On the other hand, three out of four male and one non-binary participants explored their leisure cycling as well as commuting to work. This might be closely related to the values and expectations society as a whole imposes on individuals, but it might be reinforced by the maps we produce. Geography and Volunteered Geographic Information (VGI) are dominated by men and a male perspective [SCDN22]. Gardner [GMDSD20] thesis finds that 87% of the overall contribution to OSM is by male contributors. The difference in the type of route choice between genders has been observed [BWB12, AD17] and has shown that women choose quieter routes and are more likely to travel further in pursuit of what they perceive as safety. However, the male participants in this study have also discussed routes that are longer but preferred as they are perceived to be safer or more pleasant.

All of the maps that were favoured by participants had water and green areas, such as the London canal network and parks. These are also areas where cyclists and pedestrians share paths. There has been limited research into the dynamics and effects of this practice. The study conducted in 2016 has found that path sharing can lead to animosity between users and degrade user experience [Del16]. Clash with pedestrians was one of the most frequent themes and has been mentioned by six participants in eleven instances.

Furthermore, in two of the sessions, one of the themes that emerged was the impact of hidden disabilities, such as diabetes or anxiety, on the route choice and experience of cycling. While it is difficult to establish a figure for the number of hidden disability sufferers in general, Diabetes UK estimates that 1 in 16 people suffer from diabetes.

Looking at the work done, the outputs, and the results of the analysis, the indications are that maps are an effective way to engage cyclists in reflection, as the majority of the people are willing to engage with them and they elicit narrative responses that contain new insights. The features contained in the maps can have a strong influence on the content of the narrative, as we can see in the case of the repair stops, which were one strong cycling feature present in the maps, and which were mentioned by seven participants. Also, the colour palette itself influences participants, as Participant Eleven associated the light Google map with summer (drawing ice cream) and Participant Ten associated the dark OSM Transport map with dark winter evenings. Both participants reflected on the impact of seasons on their cycling routines. Temporal change in cycling conditions is present in the literature [IPDGV12] but seasonality has been less explored, although it seems to be a significant factor.

While most people embraced maps, confidence in their drawing ability presented a barrier [Bux07]. Six participants who were confident when it came to expressing themselves visually, produced maps and sketches with more content.

Lastly, it is necessary to recognise the limitations and restraints of this work. Maps are abstractions and approximations of the world and as such bring their creator's biases with them. They are a realisation of intention and materialisation of standpoint. As such, they situate the reader in their virtual landscape. When seeking insight based on maps, it is important to take into account biases that might be present. There are more than two dozen biases identified that affect human behaviour and perceptions. The most relevant to this work is **anchoring bias**, where the starting point (in this instance maps) influences the direction of the narrative [TK74]. We aimed to minimise the effect it has by providing a wide range of maps that would provide an array of points. However, this exposes another type of bias, **familiarity bias** which is a preference for staying within a comfort zone of what we already know or recognise [TK74]. We feared that due to the familiarity bias, all participants would strongly gravitate towards Google Maps as their use is so widespread. This was true in that Google was an entry map (the first to be examined by 50% of the participants) but in the whole of the study, it was not used predominantly or exclusively. In conclusion, while efforts were made to mitigate biases such as anchoring and familiarity bias in the study, it is imperative to acknowledge and address the inherent limitations and influences of maps as subjective representations of reality.

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