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ARTICLE

Conceptualizing cycling experience in urban design research: a systematic literature review

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Department of the Built Environment, Eindhoven University of Technology, Eindhoven, The Netherlands

ABSTRACT
By conceptualizing a link between the cycling experience and the associated methods in understanding the former, the perspective of a cyclist is highlighted as an opportunity for research in urban design. A systematic review of 20 empirical papers across a variety of disciplines covering both walking and cycling experiences was conducted. This paper links social, sensory and spatial experiences, and connects these experiences to textual, visual and evaluative methodologies. This paper proposes how cycling can be considered in design research; it also provides an insight into how various methods enhance our understanding of cyclists and their surroundings.

1. Introduction
Recent reviews of the cycling literature reveal that cycling as an urban design phenomenon has been well researched in terms of measurable neighbourhood design qualities such as street grids, cycle lanes, setbacks and presence of urban greenery; yet, there exists less research that targets the subtler design aspects affecting cyclists that urban designers have long known to affect the pedestrian experience. Most research conceptualizes cycling in quantitative terms, and is mainly dominated by findings from the fields of travel behaviour, transportation planning and health science that examine the determinants of cycling (Forsyth and Krizek 2011; Heinen et al. 2010). However, this line of research about the benefits and determinants of cycling accepts a framework that emphasizes the rational reasons for people choosing different transport modes whilst leaving the qualitative experience of cycling much less understood (Koglin and Rye 2014; Spinney 2009; Willis, Manaugh, and El-Geneidy 2015). Spinney (2009), for example, identifies the lack of attention paid to the embodied and sensory aspects of mobility because most transport research uses a framework that focuses on travel time as cost of moving from origin to destination. This is clearly illustrated by looking at the six “D variables” of travel – density, diversity, destination accessibility, distance to travel, demographics and design (Ewing and Cervero 2010; Hassan et al. 2015). Much attention has been paid quantitative study of the first five “D variables”, whilst defining and

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measuring the sixth variable – design – has resulted in a new research outside of the traditional field of transport that invites the application of qualitative methods to the study of cycling experience and urban design.

Just as urban designers have specialized in understanding details that make a delightful walking experience, Forsyth and Krizek (2011) argues that certain pedestrian design logics can be applied to designing for cycling. Hamilton-Baillie (2004) juxtaposes these two design logics as “traffic zone” for car space, which is the domain of traffic engineers and “social zone” for sidewalk space, which is the domain of urban designers. Our problem is, it is not clear in which zone, and to which logic, cycling belongs. Given the slower speed of cycling compared with automobiles and a cyclist’s direct exposure to the environment, the experience of cycling may be better understood by engaging with the urban design literature on walking. A flower is a blur from the windscreen of a car but could bring delight to the slower pace of the cyclist and pedestrian. Hence, attention to detailed design is more noticeable by slower modes, and urban designers pay particular attention to the details experienced at the street level (Bosselmann 2007; Gehl 2011). In this sense, the experiential dimensions of walking as articulated by Ewing and Handy (2009) – imageability, enclosure, human scale, transparency and complexity – highlight a range of concerns that may be relevant to the cyclist, providing opportunities to complement research about the macro relationship between built environment variables with a nuanced understanding of the micro street-level characteristics that affect the experience of the cyclist throughout a journey.

In terms of linking cycling experience to urban design, this literature review reveals the problem of generalizing detailed spatial qualities at smaller scales, such as a particular bridge, a section of bike path or a building in a city, to general universal qualities that can be applied in different contexts. For example, the evaluation of particular spatial environments can use images and interviews to identify qualitative differences in urban design, but is restricted to smaller sample sizes of people’s opinion in specific spatial settings (Manton et al. 2016; Stefánsdóttir 2014). On the other hand, larger-scale data-collection methods such as travel surveys and GPS tracking use quantitative data to compare and analyse patterns in cycling behaviour patterns, but offer highly aggregated explanations about the reasons for cyclists’ behaviour. In other words, the quantitative method for capturing how people travel loses information because it must generalize and quantify information from large data sets. Thus, aggregated quantitative methods are at odds with the goal of obtaining in-depth research about the qualia of subjective experience and cyclists’ unique experiences of travel.

This leads us to examining the “black box” of travel as an important critique of transport research that we seek to unpack. In relation to cycling, Fernández-Heredia, Monzón, and Sergio (2014) argues that,

The fact that the classic factors which determine transport user behaviour – such as cost and time – are not as influential regarding bicycles use as for other modes may indicate that these other kinds of factors of a psycho-social type gain importance in the correct characterization of cyclist behaviour.

This review is also an attempt to take an inventory of new academic research on cycling experience since Law and Urry (2004) offered the critique that “existing stationary methods have difficulty dealing with the sensory – that which is subject to vision,
sound, taste, smell; with the emotional – time-space compressed outbursts of anger, pain, rage, pleasure, desire, or the spiritual.” To capture cycling experiences on a moment by moment basis, the perspective of the cyclist has recently been studied through the application of mobile methods. The use of video and ride-along interviews has been especially informative in capturing the experience of cyclists in motion (Latham and Wood 2015). Others have focused on how cyclists mediate their exposure to the environment through devices such as headphones (Jungnickel and Aldred 2014). By including mobile methods, the field of mobilities research advances tools for exploring the user perspective of cycling in real-time, and reveals cyclists’ strategies for interacting with unpleasant and pleasant aspects of infrastructure. Therefore, the mobilities’ scholarship offers urban designers tools for understanding cycling as a mobile experience in addition to the static exploration of aesthetic elements in urban design.

As cycling involves a relationship between the cyclist and the environment mediated through movement, urban designers have a clear contribution to make to the understanding of cycling, especially from the lens of experience (Forsyth and Krizek 2011; Stefansdottir 2014). Forsyth and Krizek (2011) identifies urban design research as an opportunity to contribute to the existing body of quantitative research, where cycling has been viewed primarily in functional terms in relation to urban design, noting that comparatively less research has been done on the aesthetic and experiential aspects of cycling. This review uses a systematic literature review to explore overlaps and gaps in current research on the relationship between cycling experience and urban design. The goal of this literature review is twofold: 1) to provide an overview of methodologies used to conduct research on urban design and cycling experience, and 2) to link these methodologies to theories that are used to conceptualize the cycling experience as the latter relates to urban design. In doing so, this paper sets forth how the social, spatial and sensory aspects of cycling experience can be researched through the application of relevant methodologies.

2. Methodology

To obtain an overview of the methodologies used to study cycling experience and urban design, a broad search for topics relating to cycling experience and urban design was conducted using Google Scholar, Scopus and Web of Science. The most important attributes for locating sources were as follows: publication year after 2006; relevance to urban design; and reference to the experience of mobility, including walking, cycling and other transport modes. The initial literature search found that the term “urban design” lacks a precise definition in relation to cycling, and the search term “cycling urban design” yielded many results from public health, transportation planning and land-use planning disciplines. Through reading abstracts, the search revealed that “urban design” associated with cycling is mostly used in conjunction with other disciplines, such as public health, planning, transport and land-use.

Upon further exploration, the search term “experience” was added to the literature search, which narrowed the scope too far for non-contextual search engines. The term {bicycle OR cycling OR cyclist AND experience AND “urban design”) yielded only eight results on Scopus and {cycling experience “urban design”) yielded 10 results on Web of Science. Google Scholar, on the other hand, yielded about 16 400 results using the term
{cycling experience “urban design”). Google Scholar was found to be the most appropriate search engine because Google Scholar includes academic literature in non-traditional sources, such as peer-reviewed architectural journals and peer-reviewed book chapters.

Out of 13 400 results listed on Google Scholar, the software “Publish or Perish” was used to compile the first 200 search rankings, following the recommendation by Haddaway et al. (2015). Books and other non-peer reviewed works were also eliminated. The abstracts of the remaining papers were reviewed for relevance to movement experience and urban design. Following an initial full text review, 40 out of the original 200 articles were deemed directly relevant to the topic of cycling experience and urban design, and therefore included for detailed reading. When considering final inclusion in this review, each paper’s relevance to the following question was considered: “Which methodologies have researchers used to study the experience of cycling and movement in urban design?” Using these criteria, 20 empirical papers with clear methodologies were selected for this review. Out of these final 20 papers, 14 contained a variant of the word “cycling” in the title, as indicated by an asterisk by their title in summary table. Literature reviews and theoretical papers were kept in a database and used to connect this paper’s focus on empirical methods with the wider academic discourse on urban design and cycling experience.

3. Methods of studying experience

The following section provides a summarized inventory of methods used by the 20 papers included in this literature review, and categorized in this section as textual, visual and evaluative methodologies. Table 1 summarizes the methods used in each of the 20 papers by year of publication, providing the basis for later discussion in this paper that examines how these methods can be connected to improve our understanding of cycling experience as social, sensory and spatial experiences.

3.1. Textual methods: surveys, diaries and interviews

Of the articles reviewed, surveys of cyclists were the most popular method of ascertaining cycling experience by evaluating preferences. The advantage of surveys is a large sample size; yet, the disadvantage is the tendency towards yielding quantitative data in the aggregated results. Three papers that use surveys to analyse cycling in the

<table>
<thead>
<tr>
<th>Step</th>
<th>Process</th>
<th>Remaining Articles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Google Scholar search using software “Publish or Perish”</td>
<td>200</td>
</tr>
<tr>
<td>2</td>
<td>Eliminate books</td>
<td>151</td>
</tr>
<tr>
<td>3</td>
<td>Eliminate non-peer-reviewed academic articles, conference proceedings and inaccessible articles</td>
<td>141</td>
</tr>
<tr>
<td>4</td>
<td>Using title and abstract identify articles not relevant to movement experience in urban design</td>
<td>87</td>
</tr>
<tr>
<td>5</td>
<td>After initial read, identify and exclude articles unrelated to movement experience in urban design</td>
<td>40</td>
</tr>
<tr>
<td>6</td>
<td>Identify empirical papers that contain a clear explanation of their methods. At least half of final articles must include variant of “cycling” in title.</td>
<td>20</td>
</tr>
</tbody>
</table>
### Table 2. Reviewed papers and their methodology.

<table>
<thead>
<tr>
<th>Year</th>
<th>Authors</th>
<th>Title (* = bicycle in title)</th>
<th>Methodology</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>J Dill, K Voros</td>
<td><em>Factors affecting bicycling demand: initial survey findings from the Portland, Oregon, region</em></td>
<td>Survey and GIS</td>
<td>Transportation Research Record</td>
</tr>
<tr>
<td>2010</td>
<td>J Middleton</td>
<td>Sense and the city: exploring the embodied geographies of urban walking</td>
<td>Surveys, experiential walking, photo diaries and in-depth interviews</td>
<td>Social &amp; Cultural Geography</td>
</tr>
<tr>
<td>2010</td>
<td>M Winters, M Brauer, EM Setton, K Teschke</td>
<td><em>Built environment influences on healthy transportation choices: bicycling versus driving</em></td>
<td>Survey and GIS</td>
<td>Journal of Urban Health</td>
</tr>
<tr>
<td>2010</td>
<td>M Winters, K Teschke</td>
<td>Route preferences amongst adults in the near market for bicycling: findings of the cycling in cities study</td>
<td>Survey: stated and revealed preferences</td>
<td>American Journal of Health Promotion</td>
</tr>
<tr>
<td>2010</td>
<td>M Winters, K Teschke, M Grant</td>
<td><em>How far out of the way will we travel?</em> Built environment influences on route selection for bicycle and car travel</td>
<td>Survey and GIS</td>
<td>Transportation Research Record</td>
</tr>
<tr>
<td>2011</td>
<td>M Tight, P Timms, D Banister, J Bowmaker, …</td>
<td><em>Visions for a walking and cycling focused urban transport system</em></td>
<td>Scenario building</td>
<td>Journal of Transport Geography</td>
</tr>
<tr>
<td>2011</td>
<td>D McCarthy</td>
<td><em>I'm a Normal Person</em>: An Examination of How Utilitarian Cyclists in Charleston South Carolina Use an Insider/Outsider Framework to Make Sense of Risks</td>
<td>Interviews</td>
<td>Urban studies</td>
</tr>
<tr>
<td>2013</td>
<td>PP Koh, YD Wong</td>
<td><em>Influence of infrastructural compatibility factors on walking and cycling route choices</em></td>
<td>Interviews, surveys, ride-along and infrastructure audit</td>
<td>Journal of Environmental Psychology</td>
</tr>
<tr>
<td>2013</td>
<td>B Snizek, TAS Nielsen, H Skov-Petersen</td>
<td><em>Mapping bicyclists’ experiences in Copenhagen</em></td>
<td>Route mapping: GPS and recall</td>
<td>Journal of Transport Geography</td>
</tr>
<tr>
<td>2013</td>
<td>J Van Duppen, B Spierings</td>
<td><em>Retracing trajectories: the embodied experience of cycling, urban sensescapes and the commute between “neighbourhood” and “city” in Utrecht, NL</em></td>
<td>Ride-along: participant led</td>
<td>Journal of Transport Geography</td>
</tr>
<tr>
<td>2013</td>
<td>C Nuworsoo, E Cooper</td>
<td><em>Considerations for integrating bicycling and walking facilities into urban infrastructure</em></td>
<td>Survey: stated and revealed preferences</td>
<td>Transportation Research Record</td>
</tr>
<tr>
<td>2014</td>
<td>A Hull, C O’Holleran</td>
<td><em>Bicycle infrastructure: can good design encourage cycling?</em></td>
<td>Infrastructure audit: level of service</td>
<td>Urban, Planning and Transport Research Landscape and Urban Planning</td>
</tr>
<tr>
<td>2014</td>
<td>J Bergeron, S Paquette, …</td>
<td>Uncovering landscape values and micro-geographies of meanings with the go-along method</td>
<td>Go-along: participant led</td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>N Stevens, P Salmon</td>
<td>Safe places for pedestrians: Using cognitive work analysis to consider the relationships between the engineering and urban design of footpaths</td>
<td>Work domain analysis</td>
<td>Accident Analysis &amp; Prevention</td>
</tr>
<tr>
<td>2014</td>
<td>H Stefánsdóttir</td>
<td><em>Urban routes and commuting bicyclist’s aesthetic experience</em></td>
<td>Route mapping: recall</td>
<td>Form Akademisk – Research Journal of Design and Design Education</td>
</tr>
</tbody>
</table>

(Continued)
Vancouver, Canada area illustrate how survey data sets with large sample populations can be used in cycling research (Winters et al. 2010a; Winters and Teschke 2010; Winters et al. 2010b). In these surveys, trip data from telephone surveys were used to collect trip information such as origin, destination and mode choice. A combination of Geographic Information Systems (GIS) and survey data was used to determine routes. Physical environment measures, such as greenery, air pollution and topography were available based on geographic information. Road network characteristics also measured street connectivity, road type, bicycle infrastructure type, density and land-use type. Nuworsoo and Cooper (2013), just like Winters and Teschke (2010), uses a survey to compare the results of revealed preference and stated preference of cyclists when measuring cycling facility preference. Both studies segmented cyclists according to their cycling frequency and seasonality, revealing differences between user groups with different travel patterns. Studies of this type, using both revealed and stated preferences, show differences between what people say they do versus the results of their travel behaviour.

Attitudes and perceptions towards travelling are usually missing from large-scale travel surveys that normally focus on frequency, destinations and demographics. Dill and Voros (2007) noted that travel diaries over a short period of time are not ideal for recording infrequent cycling trips. By including targeted questions about attitudes, the McGill Travel Survey in Montreal, Canada, focused on examining the role of attitudes in relation to commute satisfaction (Willis, Devon, and El-Geneidy 2013). The survey targeted students, faculty and staff, where researchers considered “bikeability” as measured by elements of the built environment and combined this information with the satisfaction of commuters as rated in their survey. By also using the information about their seasonal travel patterns and motivation, respondents were categorized into groups, including: cycling enthusiasts; exercise and convenience-motivated transit riders; convenience-motivated transit riders; convenience-motivated walkers; active environmentalists and year-round cyclists. By categorizing cyclists by also considering their attitudes as well as their use of other transport modes, the attitudes and perceptions of cyclists can be generalized according to the characteristics of their trip patterns.

Similar to surveys, travel diaries are used to record travel behaviour periodically over a longer period of time, which is useful in following variations in a group of participants over time. Boker et al. (2015) uses travel diaries in combination with hourly weather data to ascertain the relationship between the built environment, weather patterns and travel

### Table 2. (Continued).

<table>
<thead>
<tr>
<th>Year</th>
<th>Authors</th>
<th>Title (* = bicycle in title)</th>
<th>Methodology</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>L Böcker, M Dijst, J Faber, M Helbich</td>
<td>En-route weather and place valuations for different transport mode users</td>
<td>Travel diary, weather data</td>
<td>Journal of Transport Geography</td>
</tr>
<tr>
<td>2015</td>
<td>SH Ameli, S Hamidi, A Garfinkel-Castro, ...</td>
<td>Do better urban design qualities lead to more walking in Salt Lake City, Utah?</td>
<td>Pedestrian counts, GIS, block-face measurements</td>
<td>Journal of Urban Design</td>
</tr>
<tr>
<td>2016</td>
<td>R Manton, H Rau, F Fahy, J Sheahan, ...</td>
<td>*Using mental mapping to unpack perceived cycling risk</td>
<td>Route mapping: recall</td>
<td>Accident Analysis &amp; Prevention</td>
</tr>
<tr>
<td>2016</td>
<td>M Johansson, C Sternudd, M Kärnholm</td>
<td>Perceived urban design qualities and affective experiences of walking</td>
<td>Go-along: researcher led</td>
<td>Journal of Urban Design</td>
</tr>
</tbody>
</table>
satisfaction. Travel diaries asking about perceived weather and spatial quality were collected for two randomly assigned days in different seasons and combined with GIS and detailed weather data to estimate the actual spatial environment and weather conditions of the route.

Interviews result in a much more detailed textual transcript about participants’ experiences and are used by researchers to gather qualitative data about perspectives and experiences of or about people who cycle. For example, McCarthy (2011) conducted interviews with utilitarian cyclists in the Charleston, South Carolina, area in the U.S.A. and mentions consideration for the city’s size, transport plan, climate and illustrated by a map. Participants for the interview were chosen through a snowball sample. The interviews follow a naturalistic mode of inquiry, focusing on the narrative of relatively affluent utilitarian cyclists who travel by bike even when they can afford a car. Interviews are broken down by gender, race, participation and duration in utilitarian cycling, perception of risk and perception of anti-bike culture. McCarthy uses direct quotes from participants, which emphasize the subjective experience of individuals in relation to their specific cycling context. Other interviews are often analysed in conjunction with a survey to obtain quantitative or categorical data.

### 3.2. Visual methods: map drawing, infrastructure audits and go-along

Although people’s exact location can now be tracked with modern smartphones, drawing maps can help participants recall information about their travel route. Snizek, Nielsen, and Skov-Petersen (2013) performed a study in Copenhagen, Denmark, where participants were asked to draw their most recent route and designate three locations with positive experiences and three with negative experiences. These data points were compared with planning variables such as facility type, density, land use and greenery. Snizek, Nielsen, and Skov-Petersen (2013) noted that route drawing as a method to recall trips has become rare as GPS tracking and other electronic data-collection tools are becoming much more popular in research. A similar method was used by Stefánsdóttir (2014) in the cities of Reykjavík, Trondheim, and Odense, where she asked participants to sketch their route and collected information about cyclists’ background and the physical features in their commuting routes. The best and worst parts of routes were then identified on these sketches and examples were given using street scene pictures as a way to compare street-level urban design characteristics. In Ireland, Manton et al. (2016) asked participants to sketch their regularly used cycling routes and colour each route section according to their perception of safety by section: green for safe, amber for unsafe and red for very dangerous. These coloured maps were then compared with road infrastructure and urban design characteristics on the identified road segments.

Infrastructure audits aim to understand the effects of infrastructure on the experience of cycling. Hull and O’Holleran (2014) used an infrastructure audit to measure infrastructure and built environment characteristics. This is done using the “Level of Service” concept using eight categories of measurement to capture the quality of cycling routes. Their bicycle infrastructure audit included the following factors: coherence, directness, attractiveness, traffic safety, comfort, spatial integration, experience and socio-economic value. These factors form a qualitative audit to capture the different user perceptions on the comfort, speed and safety of cycling infrastructure. This study also incorporated a
ride-along method where researchers used an experienced cyclist accompanied by an infrequent cyclist whilst recording a video of the route. In Singapore, researchers Koh and Wong (2013) incorporated three types of methods in their infrastructure audit. Their experimental design consisted of three parts: 1) participants were first asked about their route details using interviews at train stations for last mile trips, followed by a mail-back survey, 2) participants drew a map of their commute and 3) researchers audited the routes based on 11 infrastructure compatibility factors and used these ratings to establish their Safety and Accessibility Index. Through a combination of surveys, mapping and auditing, researchers were able to identify shortcomings in infrastructure, focusing on areas where participants deviated from the shortest available route.

Originating from the walking literature, the go-along method can be used to assess perceived urban design qualities. The go-along method can involve planned and unplanned routes. Johansson, Sternudd, and Mattias (2016) asked participants to complete a pre-planned walk in Malmo, Sweden, for 1–2 h. Along the route, participants completed questionnaires that asked about topics including perceived urban design qualities, affective experience, and walking intentions. The study areas were selected to have similar macro characteristics such as access to transit, car ownership, distance to city centre, and neighbourhood demographics. Researchers assessed urban design qualities such as complexity and aesthetic quality; well-kept greenery and upkeep and order. Other researchers use the go-along method in conjunction with other methods. Middleton (2010) authored a study that used a mixed-method approach involving surveys, experiential walking, photo diaries and in-depth interviews. Bergeron, Paquette, and Poullaouec-Gonidec (2014) used the go-along method to explore the meanings that residents attached to a neighbourhood in Montreal, Canada. In this study, a small sample of 10 participants acted as tour guides on unplanned routes to lead the researcher through the neighbourhood using a combination of walking and driving. The tour was tracked by GPS that was synchronized with interview information obtained during the tour. Through cartographic analysis of the GPS data and discourse analysis of the on-route interview, the researchers were able to uncover micro-geographies that held significant meaning for the residents. When the go-along method is applied to cycling, it is named a ride-along where the researcher cycles with the research participant. Van Duppen and Spierings (2013) performed ride-along interviews on people’s typical cycling commutes in Utrecht, the Netherlands, by accompanying cyclists during typical daily activities. Researchers asked questions, listened and observed the participants. The ride-alongs were recorded using audio, video and GPS.

### 3.3. Evaluative methods: cognitive work analysis, visioning and visual assessment survey

Researches have also used methods to directly evaluate the environment and its influence on cycling experience. These methods include Cognitive Work Analysis from human factors engineering, visioning exercises to imagine future scenarios and visual assessment surveys from urban design.

Stevens and Salmon (2015) takes Work Domain Analysis (WDA), originally developed from the field of human factors engineering, and applies this framework to the sidewalk environment. In order to adapt WDA to urban design, the authors consulted three
sources of knowledge: 1) design and engineering guidelines, 2) the literature on urban design and 3) actual footpath circumstance. Example cases were taken from the Australian context, and urban planners and human factors’ engineers then reviewed the draft WDA. This framework divides the analysis of space into five domains: functional purpose, values and priority measures, purpose-related functions, object-related processes and physical objects. In each of these domains, specific analysis takes place related to the other domains.

Visioning is a method used to envision future scenarios for urban design. Tight et al. (2011) developed visions for five areas in a medium-sized U.K. city, each with one current and three future scenarios with urban design models. The visions have been developed by a review process that includes discussion amongst the members of the research team consisting of expertise in transport planning, mathematical modelling, urban design, socio-cultural change and computing sciences. In developing these visions, there were also extensive discussion with stakeholders and experts through a series of workshops, project meetings and presentations. Tight et al. (2011) focuses on the creations of these visions; yet, the realization of, and the pathways to these visions, is left for a future study.

Urban designers have also attempted to quantify what have been so far unquantifiable urban design qualities. Hassan et al. (2015) looked at quantified measures of urban design characteristics in Salt Lake City, U.S.A., as described by previous urban design research (see Ewing and Handy 2009). Ameli et al. uses quantitative measures to describe Ewing and Handy (2009) urban design variables of imageability, legibility, enclosure, human scale, transparency, linkage, complexity and coherence. Then, Hassan et al. (2015) locates these variables in a neighbourhood in Salt Lake City, U.S.A., defines the gross neighbourhood characteristics, and compares these variables to pedestrian counts. Through this method, Hassan et al. (2015) were able to further refine the important urban design variables to imageability and transparency. A similar method analysing cycling routes could yield insights for the urban design variables that are most important for the cycling experience.

4. Cycling experience as phenomenon

This section links the methods with three broad categories of experiences that these methods seek to capture: 1) social experience, 2) spatial experience and 3) sensory experience. For the social experience, some factors appear to be presence of people on streets, society’s acceptance of cycling and the socio-economic characteristics of cyclists. Cycling is connected to experiences of social marginalization and neighbourhood quality whilst counting the presence of people on the street can be a proxy to measure how much people enjoy public space. For the sensory experience, some perspectives are equipmentality, weather, legibility and perceived safety. Flow and perceived safety frame an individual’s perception of the environment whilst interacting with more tangible perceptions such as noise, smells and weather. For the spatial experience, studies illustrate the importance of building scale, weather mitigation using trees and buildings, and spatial landmarks. For the spatial experience, different scales of the city from architectural landmarks to streetscape design merge to produce the legibility of space as experienced through movement. These aspects of cycling experience are
derived from the content of the reviewed empirical studies, and the goal of this section is to explore how the methods reviewed earlier in this paper can be used to connect the various aspects of cycling experience as a multi-dimensional phenomenon.

### 4.1. Social experience

The social experience of cycling can be captured by qualitative methods where participants are open to express their feelings. McCarthy (2011) uses an extensive interview and direct transcriptions of responses to communicate how cyclists can feel socially marginalized in society, especially deriving from the interactions between cyclists and other road users. McCarthy (2011) finds that, “not only do cyclists list a host of risks attributable to driver behaviour and attitudes, but they have also formed, through the process of sense-making, a common framework that explains the origins of the risks posed by drivers”. Bergeron, Paquette, and Poullaouec-Gonidec (2014) uses the go-along method and engages in a mobile interview to capture how different places can evoke both positive and negative feelings associated with walking. From these mobile interviews, it is evident that participants often highlight social activity as the defining aspect of neighbourhoods. One participant observed, “There are less people outside in the streets than before. For several years now, we’ve noticed that people live inside their homes.” (Bergeron, Paquette, and Poullaouec-Gonidec 2014)

In societies where cycling levels are low and where not everyone has had the experience of riding a bike, regular drivers and users of other transport modes see cyclists as outsiders, rather than as normal participants in the transport system, and cycling is thus marginalized as a social activity, and in some places, is acceptable only as a leisure activity (Spinney 2008; McCarthy 2011). This marginalized experience can be related to places where walking for transport is also not an accepted activity. If social attitudes delegitimize the activity of walking or cycling, the transport activity itself becomes an anti-social act that is to be avoided. Middleton (2011) describes a pedestrian

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**Figure 1.** Conceptualizing cycling experience as social, sensory and spatial phenomenon
in the United States as someone who cannot afford a car, who does not have access to the security that comes with driving and, thus, must experience the city as a hostile jungle.

Quantitative methods have also been used to capture the social experience. The number of people on the street, for example, is used as a quantitative indicator of public space quality in relation to various aspects of the built environment (Hassan et al. 2015). Other studies segment cyclists according to socio-economic characteristics, demographic characteristics, and values and perceptions (Willis, Devon, and El-Geneidy 2013). This segregation can imply the importance of the social dimension to cycling, as Paige Willis, Devon, and El-Geneidy (2013) observes that “the difference between showing that physical characteristics of a cycling trip (which include distance, slope, land uses, density, and connectivity) do not lead directly to trip satisfaction but are filtered through socio-economic factors (age, income, gender).” In turn, these socio-economic factors may be a strong indication of peer groups and how different social environments result in different perceptions and experiences of cycling.

4.2. Sensory experience

Researchers have observed that cycling is a sensory experience that sets it apart from other transport modes. For example, cycling embodies a sense of energy expenditure, risk perception, weather conditions, urban activity and what Middleton has called “equipmentality” (Manton et al. 2016; Middleton 2010; Spinney 2008).

Middleton’s (2010) observation of the equipmentality of walking can be applied to cycling research because the bicycle serves as the equipment of cycling. In this way, the mediated experience of walking and cycling can be studied through similar lenses. For example, Middleton writes about how shoes can influence the walking experience; that “…shoes can be understood as part of such a hybrid unit of analysis (human–socks–shoes – pavement). … [where] shoes ‘intervene’ and ‘disrupt’ the ‘flow’ between… body and the pavement” (Middleton 2010). In this framework, the quality and type of bicycle can also be considered in the context of disruption and flow. Just as walking feels different when pushing a stroller or when carrying a heavy backpack, cycling can feel different depending on the weight of the bike and the mounting of luggage. Along with different styles of walking, there are various styles of cycling, most notably the difference between those who are cycling to work and those who are cycling for recreation. Middleton (2010) also points out how considerations of pedestrian logistics are incorporated into urban design, where one finds ramps for strollers, luggage and wheelchairs. In this way, the study of infrastructure and pedestrian logistics can be seen in presenting similar challenges as those experienced by cyclists in relation to bike paths and other cycling infrastructure.

Weather is another area of research that closely relates to the sensory aspects of cycling. Although focused on the effects of weather, Boker et al. (2015) derives the important conclusion that,

besides the effects of weather, …emotional travel experiences differ substantially between the different transport modes. Being more intensely and intimately connected to their
physical surroundings while travelling, active mode users have overall more positive en-route place valuations than public transport and especially car users (Boker et al. 2015).

However, the opposite is true in bad weather. Cold, windy or wet weather has a much stronger negative effect on active modes such as cycling. This research confirms intuition not only the relationship between weather and active modes, but also the lesser effect that weather has on the experience of place through the mediated environment of an enclosed vehicle (Boker et al. 2015).

Safety is an aspect of cycling that can be viewed as having both a sensory (perceived) risk and as an objective risk. Exploring the sensory component reveals how much danger cyclists feel themselves to be in, whilst quantitative measure of risk, such as in deaths per kilometres travelled, focuses on the objective risk of transport. Manton et al. (2016) uses a colour-mapping approach to measure perceived risk, which is likely more important to the cycling experience than objective risk, and empirical studies have supported this view (Winters et al. 2012). Whereas objective risk can be measured through observation of crashes and hospitalization data, the sensory perception of risk, such as near-misses requires engagement with people’s opinions of their environment. Manton et al. (2016) argues that this subjective perception may be influenced by infrastructure design, traffic volumes, attitudes, social norms and habits that relate to the social and spatial aspects of experience.

There are other aspects of unquantifiable sense and feeling, such as the smell of coffee and the feeling of home that can be revealed by a ride-along method. For example, Van Duppen and Spierings (2013) studied sensory landscapes between home and work in Utrecht and discovered that participants described sensory experience in terms of not just noise, traffic and weather, but also architecture, mental focus, rhythm and chaos. In this sense, an open ride-along method that follows participants through their usual routes has produced, “…insights into the composition of diverse urban sensescapes – ways in which environments are sensed and tactics applied through the body” (Van Duppen and Spierings 2013). Thus, the interpretation of the cycling environment relates to personal preferences, intentions and memories, so the same physical sensation can be experienced differently depending on each person’s own history.

4.3. **Spatial experience**

When thinking about urban design, people’s experience of space is a fundamental consideration when designing environments. One of the methods encountered during this literature review is the idea of using visioning exercises to build conceptions about how neighbourhoods can be developed in the future (Tight et al. 2011). By visually sketching the alternative future visions of urban space, cycling is considered in the context of designing high-quality urban environments rather than as traffic to be forecasted, accommodated and managed.

Spatial design that considers cycling experience can be informed by research that relates space to other aspects of experience. For example, trees, shelters and wind barriers can be used in public spaces to make bad weather more tolerable and enhance the liveability and usage of outdoor environments (Boker et al. 2015). Likewise, framing the perception of space from a safety perspective can lead to urban design that is not
only objectively safe for the cyclist in terms of reducing collision rates, but also afford an 
enhanced level of subjective social and traffic safety that makes cyclists feel welcome in 
that space (Manton et al. 2016). The application of WDA, as suggested by Stevens and 
Salmon (2015), can give urban designers the tools to think about cycling in terms of affordances and how the needs of users relate to objects and artefacts in their 
environment.

The strong association between cycling and space is revealed in not just quantitative 
measurements of urban infrastructure such as bike lanes, greenery and street connec-
tivity (Willis, Devon, and El-Geneidy 2013; Winters et al. 2011), but also embedded in 
meanings and relationship to urban space as encapsulated in the work of Lynch (1960) 
to modern psycho-geographers. In this broader sense, architecture and landmarks play 
an important role in defining space. For example, cyclists in the Utrecht study men-
tioned prominent features such as bridges, canals and buildings as key aspects of their 
experience (Van Duppen and Spierings 2013). Authors such as Hassan et al. (2015) have 
attempted to quantify and test the significance of both small-scale and large-scale urban 
design variables with the number of people on the street. Whilst a count of cyclists in 
various cycling environments could be indicative that specific environment’s attractiv-
ness for cycling, the same count of cyclists could also reflect the status of a particular 
street in relation to other attractions in the cycling network. Hence, the spatial attrac-
tiveness of cycling environments could be complemented by qualitative evaluations of 
how elements of specific places are experienced through the lens of cycling.

5. Conclusion

This literature review demonstrates that urban design, mobilities, geography and other 
disciplines contribute valuable qualitative methods for understanding the cycling experi-
ence. Going forward, this section explores opportunities to connect and strengthen the “design” aspect of cycling research with the other five “D variables” normally associated 
with transport research – density, diversity, destination accessibility, distance to travel 
and demographics (Hassan et al. 2015). In doing so, we hope to better understand 
various aspects of cycling experience, which are often neglected when cycling is defined 
only as a tool for getting from A to B. Towards this goal, we outline three opportunities 
for further research and exploration of cycling experience in urban design and mobilities 
research.

First, we should explore how qualitative and quantitative measures of cycling could 
be linked at various physical scales, and how cycling experience could be described 
across physical scales. Te Brömmelstroet et al. (2017) observes that,

the speed of cycling results in a trade-off between the depth of interactions (relatively 
superficial), and the amount of interactions (high and distributed over a large terrain). By 
doing so, a cyclist can build a rich and large cognitive ‘image of the city’ (Lynch 1960) and as 
such develop a rich sense of connectivity.

Hence, it may be possible to use cycling experience to connect the generally quantita-
tive understandings of space, such as commuting patterns, at the city and regional 
scales to the qualitative aspects of unique experiences, such as the smell of a bakery, at 
the smaller street and neighbourhood scales. For example, where methods such as
cognitive work analysis and ride-alongs may be applicable for understanding cycling at the street scale, future research could link these location-specific methods to survey and GIS data that may be used to analyse cycling experience in relation to transport networks at city and regional levels.

Second, the experience of time, or temporal dimension of cycling is, despite our search efforts, missing from this literature review. If one of the main aims of mobilities research is to look inside the “black box of travel” beyond A to B-ism, it is imperative for us to understand how the relationship between objective time and subjective time, and emotions are mediated by experience. Here, a clear example can be taken from research into the experience of public transport, where Friman (2010) gives a couple of examples, “The train is late and this makes the traveler angry. While waiting for his or her connecting bus, the traveler feels bored.” Are there similar waiting experiences at traffic lights, queuing behind slower cyclists or waiting for automobile traffic, which affect the temporal experience of cycling? What do these experiences mean for cyclists’ perception of time?

Third and finally, building on the visioning method by Tight et al. (2011), the way forward may lie in better ways to envision, experience and test new urban design ideas before they are physically built. As technologies such as virtual reality and 360-degree video become more affordable, advances have been made in developing methods for both simulating existing places in virtual laboratory environments and creating and testing new environments that do not yet exist (Echevarria Sanchez et al. 2017). To what extent are these new technologies useful for simulating real-world experiences in controlled laboratory settings? Is it possible for stationary methods simulate mobile experiences and vice versa? What is clear from this review is that application of both mobile and stationary methods for researching cycling experience combined with the existing research in active transport has the potential to yield novel connections between cycling experience and the design of cycling environments.

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