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The power of perceptions: Exploring the role of urban design in cycling behaviours and healthy ageing

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Abstract

Good urban design has the power to aid in the provision of inclusive journey environments, yet traditionally neglects the perspective of the cyclist. This paper starts from the premise that more can be done to understand and articulate cyclists' experiences and perceptions of the urban environment in which they cycle, as part of a closer linking of urban design qualities with transport planning and infrastructure interventions. This approach is particularly applicable in relation to older cyclists, a group whose needs are often poorly understood and for whom perceptions can significantly influence mobile behaviours. Currently, knowledge regarding the relationship between the built environment and physical activity, including cycling, in older adults is limited. As European countries face up to the challenges associated with ageing populations, some metropolitan regions, such as Munich, Germany, are making inroads into widening cycling's appeal across generations through a combination of urban design, policy and infrastructure initiatives. The paper provides a systematic understanding of the urban design qualities and built environment features that affect cycling participation and have the potential to contribute towards healthy ageing. Urban design features such as legibility, aesthetics, scale and open space have been shown to influence and affect other mobile behaviours (e.g. walking), but their role as a mediator in cycle behaviour remains under-explored. Many of these design 'qualities' are related to individual perceptions; capturing these can help build a picture of quality in the built environment that includes an individual's relationship with their local neighbourhood and its influences on their mobility choices. Issues of accessibility, facilities, and safety in cycling remain crucial, and, when allied to these design 'qualities', provides a more rounded reflection of everyday journeys and trips taken or desired. The paper sets out the role that urban design might play in mediating these critical mobility issues, and in particular, in better understanding the 'quality of the journey'. It concludes by highlighting the need for designers, policy makers, planners and academics to consider the role that design can play in encouraging cycle participation, especially as part of a healthy ageing agenda.

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1. Urban Design and Cycling

Urban design research and practice has historically displayed a tendency to focus on human scale (a notion that has traditionally been defined through pedestrian movement and characteristics), with the goal of creating and encouraging vibrant public spaces and places. Research attempting to better understand or articulate cyclists' experiences of these places is however sorely lacking (Forsyth et al., 2009). This despite recognition that high quality urban design has the power to aid in the provision of more pleasant and inclusive journey environments (Azmin-Fouladi et al., 2007). In this paper we argue that more can, and should, be done to incorporate a 'cycle scale' - an awareness of, and sensitivity towards, the diverse needs of the bicycle and its user - into urban design discussions. This reimagines 'human scale' as something altogether more inclusive and interactive, accurately describing cities in which cycling culture is engrained, such as Copenhagen or Amsterdam, or in which cycling is providing a significant modal share of trips taken. Developing more tangible links between urban design, understood both as a professional practice and a series of core principles related to understanding the physical environment and place (see Table 1), with those aspects of the built environment such as street infrastructure that have tended to remain the domain of transport engineers and planners, is one way to do this (Boarnet and Crane, 2001). What limited research that has been conducted has centred on issues of user safety, cycling facilities (including lanes and parking), or creating comfortable spaces in which to encourage recreational cycling (Forsyth and Krizek, 2011). This paper contends that there is potential to extend this research into the arena of more qualitative or subjective aspects of urban design, such as individual-level perceptions of quality, legibility and enjoyment.

Table 1: Selected examples of good design principles (Adapted from CABE, 2011)

Principle of Design	Definition
Character	A place with its own identity and characteristics that make it distinctive and reflective of its local inhabitants
Continuity and Enclosure	A place where public and private spaces are clearly distinguished.
Quality of Public Realm	A place with attractive and well used outdoor areas designed with people in mind.
Ease of Movement	A place that is easy to get though and move within.
Legibility	A place that is easy to navigate through, with landmarks and clear intuitive pathways
Adaptability	A Place that can accommodate change over time, create continuity with the past and respond to new social, market, or environmental demands.
Diversity	A place with variety of choice in activities, shops, and services. Choices in employment and housing and a range of income earners.

In recent decades, a more sophisticated awareness of diverse human behaviours has helped influenced the design and planning of the built environment (Handy et al, 2002). Today, urban design criteria and principles are typically based upon an (albeit partial and potentially exclusionary, see Imrie, 2001) understanding of the 'human-scale'. This has seen designers, for example, focusing on pedestrian movement and flow, in part to counter a historical tendency to privilege automobile traffic (Rowley, 1994). While recently published design guidance for cities such as New York (NYC, 2010) suggest cycling is now being seriously considered as part of integrated urban transport networks, the use of the bicycle as an alternative not only to walking, but also motorised transport, has not yet permeated urban

design thinking to any significant level (Forsyth and Krizek, 2011).

We argue that as long as our environments remain solely geared towards vehicular usage and pedestrian flow, cycling can be classified as the '*forgotten middle*'. More optimistically, we see an opportunity to begin the process of rearticulating places from a cyclist's perspective, with the aim of improving the quality of both real and potential journeys. Jane Jacobs challenged urban professionals and researchers to look closely at our cities, and to "*also listen, linger, and think about what you see*" (cited in Gehl and Svarre, 2013, p4). In many cities across the world the modal share of cycle journeys is increasing, the reasons for this must be both recognized and further understood. Yet of equal importance is acknowledging the *absence* of cycling in many major metropolitan regions, an issue that arguably requires even more urgent attention. Questions remain as to what level of visual detail is appropriate for cyclists and how to incorporate detailing for high-speed motorists, low-speed pedestrians, and the unique characteristics of those who choose, or may consider, to cycle. Studies are required that elucidate the relationship between the (un)attractiveness of cycling conditions and routes, and the use of bicycling as an appealing and widely accessible means of transportation (Titze et al., 2008). In the absence of measures to make it more attractive, and to better understand what makes it so, the future for cycling as a viable transport option across different parts of the population (Wardman et al., 2007), is likely to remain uncertain.

While cycling remains relatively underdeveloped in relation to urban design, extant research suggests that one demographic who may benefit most from a shift in thinking is older adults. Older adults cycle less than any other demographic of the population (Pooley et al., 2013), a problem especially pertinent in the United Kingdom (UK) where less than 1 per cent of all trips among 65 year olds are by bicycle, compared to 9 per cent in Germany, 15 per cent in Denmark and 23 per cent in The Netherlands (Pucher & Buehler, 2012). As populations age across much of the developed world, it is vital for governments, policy makers, and place makers to promote and provide places and spaces that encourage and facilitate healthy ageing. Taking part in physical activity, especially when continued into older age, can generate significant savings in the provision of health and social care services, as well positively impacting on an individual's quality of life and social and mental wellbeing (Sigiyaama and Ward-Thompson, 2007). The built environment has been shown to have a significant role in the provision for, and levels of, participation in physical activity (Berke et al., 2007, De Bourdeaudhuij et al., 2003, Frank et al., 2003, Handy et al., 2002, Humpel et al., 2002, Lopez, 2012, Van Cauwenberg et al., 2011, Van Kamp et al., 2003, Wendel-Vos et al., 2007). However, conversely, hostile urban environments can create barriers to people engaging in more active lifestyles (Bortz, 1982).

This position paper is part of a 3-year EPSRC (Engineering and Physical Sciences Research Council) funded research project, 'cycleBOOM'*, designed to better understand cycling among older people (see, www.cycleboom.org). The UK-based project will employ a range of research methods, including biographic and mobile interviews, to draw attention to the factors that impede and facilitate cycling activities among the older population. This paper represents a distinct strand of the research that focuses on the role that urban design could play in facilitating cycling into later life. The first section briefly outlines the existing research literature linking features of the built environment to levels of physical (in)activity. We then explore what we term the *power of perceptions*, that is the judgments and evaluations made by individuals about their surroundings which can have a significant influence over propensity to engage in physical activity. Third, we turn our attention to the specific features of the built environment (both actual and perceived) that facilitate and/or impede cycling behaviours. We then set out a methodology for evaluating the quality of physical environment from a cyclist's perspective that also captures individuals' perceptions of these features. Finally, we conclude by arguing that there is a need for urban designers to consider the cycle scale in the creation of inclusive and active urban environments.

2. Physical Activities and the Built Environment

Physical activities such as cycling, like all human behaviours, are the product of complex reciprocal interactions between people and their environments (Lawton and Nahemow, 1973). A myriad of research has identified key urban and environmental variables influencing activities such as walking (Ball et al., 2001, Carnegie et al., 2002, Ewing and Handy, 2009, Forsyth et al., 2009, Foster et al., 2004, Gallagher et al., 2010, Owen et al., 2004, Lovasi et al., 2008). Contact with nature has also been identified as having a positive influence on people's health and

propensity to engage in some form of physical activity (Kaplan, 1995, Maller et al., 2006, Hartig et al., 2003). Partly as a result of this research, questions are now being asked about how to design communities from a both an ‘environmental’ and ‘health’ perspective (Frumkin, 2002). Such questions require professional groups within health and design sectors to take steps together to develop health-enhancing physical environments focused on people (Giles-Corti, 2006).

There is ample evidence to indicate that places can facilitate or impede physical activity, such as cycling, in part due to the level of (un)supportive infrastructure (see for example, King et al., 1995). However, a number of other features can play a significant role mediating levels of physical activity, such as access to green open spaces (Sugiyama and Ward Thompson, 2008); urban aesthetics (Ball et al., 2001); land use diversity (Gidlow et al., 2010); vacant or high rise buildings (Borst et al., 2008); tidiness (Ewing and Handy, 2009); housing quality (Barton et al., 2002); graffiti (Coleman, 1985); and the presence of human activity (Borst et al., 2009). It is worth highlighting here that different aspects of the built environment may incite or impede different types of physical activity (Stronegger et al., 2010), for example with some features (e.g. parks) providing ideal conditions to engage in walking, yet perhaps simultaneously creating barriers to cycling (for example, by forbidding cycling or using pathway materials uncondusive to cycling, such as heavy gravel).

Studies that highlight the built environment features most likely to influence (positively and negatively) physical activity generally do not focus exclusively on cycling, either as a form of leisure activity or transportation option. Instead there is a strong research focus on walking behaviours amongst communities (Booth et al., 2000, Cervero and Kockelman, 1997, Michael et al., 2006, Pikora et al., 2006, Saelens et al., 2003, Van Lenthe et al., 2005, Borst et al., 2009). The evidence from these studies suggests that *“the places where people live, work, and play, and the quality of those places, may be important determinants of walking”* (Giles-Corti, 2006, p363). For example, neighbourhoods that present more barriers to, and provide fewer resources for, the encouragement of physical activity may potentially speed up the ageing process for their inhabitants (Bortz, 1982), negatively impacting upon people’s health and quality of life. Therefore, understanding an individual’s relationship to their local environment is crucial if we are to build a fuller picture of their (mobile) behaviours, and the personal levels of wellbeing and quality of life associated with these behaviours (Moser, 2009). The following section develops this line of argument, suggesting there is a need to assess not only the relationship between urban facilities and services and the propensity to cycle, but also to understand the perceptions and evaluations that people themselves make about their immediate surroundings. These *subjective* and highly individualised *factors* can create *perceptual barriers* to making active (walking, cycling, running etc.) travel choices. We develop this discussion through the lens of the older (60+) adult, a group whose needs are often lacking from policy and research on active mobility, and particularly cycling.

3. The Power of Perceptions

“The influence of residential environments is believed to be greater for older adults than for younger adults. Older adults usually spend more time at home (increased exposure to the environment) and they are more vulnerable to environmental constraints (increased environmental docility)” (Wang and Lee, 2010, p1268).

Whilst it remains true that individual perceptions may not truthfully reflect reality (Ding and Gebel, 2012), research indicates that the characteristics of neighbourhoods, and the built environment in general, may have a more noticeable impact upon the wellbeing of older people than the rest of the adult population (Gale et al, 2011). One reason for this is, as the above quote from Wang and Lee (2010) suggests, this group’s higher level of exposure to their immediate surroundings. Older adults are less likely to go out to work and tend to have increased risk of mobility limitations. Conversely, and more positively, older adults who illicit a stronger sense of place within their local communities for example, have been shown to record more positive levels of mental *health* *“independently of their socioeconomic status, income, state of health and perceived social support”* (Gale et al., 2011, p873). Gidlow et al. (2010) concur that socio-economic factors cannot satisfactorily explain the associations between an individual’s perception of his/her neighbourhood and their health status, suggesting that further research on neighbourhood characteristics is required. Moreover, given that populations (both young and old) spend a great deal of time and resources in localities, it is important to understand how we evaluate, rate, and perceive these environments to build a more comprehensive picture of the complex relationship between the built environment and

levels of physical (in)activity (Greenberg and Crossney, 2007).

Important for our research, is the finding that older people can be particularly sensitive to the characteristics of urban form (Dannenberg et al., 2003, Tranter et al., 1991, Lovasi et al., 2008). As a result, urban design has been championed as a key component in the bid to increase levels of physical activity in older generations (Berke et al., 2007, Patterson and Chapman, 2004, Li et al., 2005). This sensitivity has been attributed to a range of variables unique in older adults, such as the physical and mental decline associated with age, reduction in social networks and support, and increased fragility (Yen et al., 2009, Shaw et al., 2007). In addition, older people are more susceptible to the influence of individual perceptions, especially in relation to issues such as personal safety, neighbourhood design, and aesthetics (Forsyth and Krizek, 2011, Townshend and Lake, 2009). This is perhaps due to the notion that older adults are perceived as more vulnerable to the influences of their immediate physical environment as they tend to travel outside of these areas less frequently than younger adults (Glass and Balfour, 2003).

Previous studies on cycling have persistently highlighted the power of perceptions with regards to levels of personal safety, with *perceived* safety often displaying more meaningful influence on mobile behaviours than recorded safety data (Winters et al., 2012). Research indicates that individual perceptions about levels of neighbourhood safety are more likely to influence levels of physical activity among adults aged 65 years and older, than for the rest of the adult population (Troped et al., 2001, p197). Perceptions can mediate between features of the physical environment, which can include architecture, infrastructure, landscaping, wider urban design principles, and mobile behaviour, with these features influencing the quality of the environment both directly and indirectly through the sensitivities of individuals as they evaluate and make judgments on their immediate surroundings. Wang and Lee (2010) recommend further studies on the relationship between the urban environment and activity amongst the older population, considering in more detail the features that can act as activity promoters or barriers at both the site and neighbourhood levels.

Perceptions of place from the individuals who populate them can be one of the key definers for neighbourhoods and towns, what is expected from a place, the way in which it is identified and valued will differ from person to person (Jenks and Dempsey, 2007). It is therefore critical that personal views and perceptions are reflected in research that attempts to better understand or improve aspects of neighbourhoods. As much is recognized by the US National Commission on Neighbourhoods which has argued that a neighbourhood or local place can be defined as “*what the inhabitants think it is*” (cited in Hallman, 1984). Moreover, given our focus on physical activity (cycling), studies have shown the “*importance of attitudes, motives, perceived benefits and barriers, self-efficacy, social influence of family and friends, and the intention to change behaviour for participation in general physical activity*” (de Geus et al. 2008, p698). Our contention is that developing a holistic understanding of 1) physical environment features, 2) urban design qualities, and 3) individual perceptions of 1) and 2) is required if we are to understand the different factors that affect people’s travel patterns and behaviours. In the following section we outline a methodology for measuring these variables as part of our aim to more clearly articulate the complex interplay between the physical urban form of place and (im)mobile behaviours.

4. Facilitating Cycling: Linking Physical Activity to the Built Environment

This section looks in more detail at the characteristics of the built environment that may facilitate physical activity, with a specific focus on increasing the propensity of the population to cycle. A range of environmental attributes are deemed of moderate or high importance in achieving higher rates of cycling (Owen et al., 2004). These include aesthetics; distance; neighbourhood environment; traffic; access; open spaces; amenities; safety; pleasurable experience; age of home; practical environment; infrastructure; convenience; neighbourhood quality; land use mix; ease of movement; street lighting; crime; and cycle lanes. Forsyth and Krizek’s (2011) research breaks down some of the finer elements of detailed design, and highlights the need to be aware of a number of key principles (highlighted in Table 2).

Table 2: Principles of detailed design (Adapted from Forsyth and Krizek, 2011).

Proportion	The visual effect of the relationships of various objects (buildings / street furniture etc.) and spaces that make up a place, to one another and to the whole.
Transparency	Ability of a place to allow its viewer to read, interpret, and understand its successive and often complex layers.
Building complexity	Balance between order and complexity in local architecture and how surrounding buildings relate to one another in place.
Character	The identity of a place, the unique characteristics that contribute to its distinctiveness and reflects the local community
Landscaping	Level of green or open space, planting, and street planting
Materials	The choice and range of visible fabrics, not only architectural facades, but also including street furniture, pavements, street art etc.
Textures	The choice and range of textures both seen and felt – including cladding, pavements, glazing, handrails etc.
Height of cyclist	Unique characteristic of a cyclist is riding height, this determines the angle that an individual will view and engage with the surrounding built environment
Speed of cyclist	The speed of cyclists will vary greatly, and will have a significant impact on how much detail of the built environment is processed
Skill diversity of cyclist	The skill of the cyclist can determine the types of environment they will engage with, and the ways in which they will interact

However, further research is required to establish exactly what level of detail is necessary to increase cycle journeys and facilitate people to engage in a physical activity. In particular, there is a need to take into account highly subjective aspects such as the visual appeal of places as well as infrastructure such as cycle routes. Understanding individual reactions to matters such as ‘aesthetics’ or ‘journey quality’ is critical in establishing how people view their surroundings, with research suggesting that variations in perceptions can significantly impact upon personal mobility and levels of physical activity (Saelens et al., 2003, Humpel et al., 2002, Ball et al., 2001, Nasar, 1994, Hoehner et al., 2005). Other even less tangible attributes such as *sense of community* or *sense of place*, that have strongly shaped urban design theory and practice are now also recognized as being a significant driver in increasing physical activity (Burgoyne et al., 2008). People are more likely to cycle in, or to, places they enjoy visually and feel a connection with, whilst conversely avoiding places that they perceive as unpleasant (Nasar, 2008). As an example, leisure cycling is often linked to quality of aesthetics and the provision of open space, yet commuter cycling is more focused on the provision of joined-up networks and the efficiency of routes, incorporating urban design principles such as legibility. We argue it is imperative to have an understanding of people’s rationale for all kinds of cycling.

For example, cycling for travel or for leisure may have a different relationship to the physical features and qualities that have been shown to facilitate cycling activities (Forsyth et al., 2008). In relation to our focus on older people, Michael et al's (2006) research suggests that for older adults, maximising the attractiveness or safety of a pedestrian path is more important than minimizing the distance to destination. This reinforces our view that design-related issues are critical in promoting active and independent mobility in later years.

There is now a strong body of research showing that cycling impacts positively on people's health by providing an opportunity to engage in a relatively low-impact and undemanding physical activity. However, just as important is attempting to understand cycling's relationship to less measurable aspects such as *quality of life* and *wellbeing*. The latter is a broad term which covers issues such as personal enjoyment and confidence, opportunities for social engagement and cognitive function. Yet, while we know the importance of built environment characteristics for individual wellbeing, few studies have integrated an analysis of quality of life into research on the built environment and levels of physical activity (including cycling) (Sarmiento et al., 2010). Built environment characteristics not only potentially influence quality of life, but it must also be recognised that it is possible that quality of life may directly impact upon physical activities, such as cycling.

Cycling should not only be promoted to increase physical fitness and encourage regular active lifestyles, but can assist in delivering positive interactions with urban surroundings for all those who choose to cycle or exercise outdoors. Borst et al (2008) argue that perceived attractiveness can cover a myriad of details and features, proffering three main attributes related to walking: tidiness, scenic value, and the presence of activity or other people. The latter category highlights the importance of the social aspect to quality within the built environment that is particularly critical for older adults and their wellbeing given the higher levels of social isolation experienced in this group (Bowling et al., 2003, Glass et al., 2006). For example, regular walking is associated with more frequent contact with friends and neighbours (Bertera, 2003), while settings that are perceived as attractive generally present more opportunities to engage with others (Sugiyama and Ward Thompson, 2008). Factors such as attractiveness have significant power therefore to deliver an environment conducive to active and healthy ageing *in place*.

Moreover, research suggests that the decision to cycle is often largely personal (Moudon et al., 2005), rather than solely based on more 'objective' factors, such as the presence of cycle-specific services or features. For example, we know that many who cycle do so irrespective of whether a supportive transport infrastructure is in place or not. In the UK, the lack of provision of quality environments for cycling is reflected in the cycling demographic which is heavily skewed towards males aged 25-35 (Pooley et al., 2011), those who already possess high levels of fitness, or have a regular active routine in place (Bull et al., 2000). The drop off in numbers into older age is startling, and we suggest that it is no coincidence that levels of cycling are so low amongst this demographic, whose behaviours are more susceptible to variations in neighbourhood design quality. Our focus on perceptual factors also recognises that cyclists, and those who may *consider* cycling, including older adults, are not a homogenous group (Tilahun et al., 2007). This indicates that any improvements to the urban environment with the express purpose of facilitating cycling and other physical activities must take into consideration a wide range of quality measures that are refracted through individual perceptions. In the following section we outline our methodology for capturing these variables in assessing the quality of the cycle journey.

5. Understanding quality in cycle journeys

There is a pressing need to better understand the components that make up the 'quality of the journey' for cyclists. This involves looking at issues such as vibrancy and aesthetics that have the potential to enhance the cycle experience (Blanco et al., 2009), as well as unlocking both the perceived and actual environmental conditions that contribute to the likelihood of cycling taking place (Moudon et al., 2005). Little work has been done to provide a more systematic understanding of the neighbourhood context and features of urban form that aid successful ageing *in place*, with knowledge regarding the relationship between the built environment and general physical activity in older adults limited (Van Cauwenberg et al., 2011). Urban design provides an ideal platform from which to assess cyclist experiences, as many of the identified and quantifiable urban design qualities, such as legibility,

transparency, and enclosure (see Table 3), reflect those variables that have been shown to influence other mobile behaviours, such as walking, and therefore are likely to also be important in mediating cycling behaviours. Ewing et al. (2006) produced a comprehensive list of urban design qualities related to walking that are, to a degree, objectively measurable (when evaluated by trained design professionals with knowledge in the assessment of the built environment), a number of which are transferable to a study of cycling (with extensive testing, of which our study, cycleBOOM, is currently engaged in). These urban design qualities are associated with the physical features of the urban environment.

It is necessary to be continuously improving the reliability and validity of both objective and perceived measures (Ding and Gebel, 2012; Owen et al, 2004) and to be combining the use of both in robust and well-rounded methodologies. Giles- Corti (2006) argues that any effective increase in physical activity across local communities will require a targeting of both people and place. The quality of an environment can be evaluated from two distinct perspectives; the technical expert's assessment, and the subject-based layperson's assessment (Bonaiuto, 2004). Moser (2009) classifies the expert led as 'objective' as it involves general measures about the qualities of the built environment, whilst the laypersons is deemed 'subjective' as it largely relies upon self-reporting tools through which individual observations and evaluations are expressed. Good urban design that seeks to be inclusive and forward thinking should always recognise the power and usefulness of both types of quality measure.

Those with the relevant extensive design training have the ability to both recognize and assess these qualities and features. For those without such training, any evaluation of the built environment is more *subjective* by nature as it is not generally based upon measurable and 'agreed' criterion, but rather upon individual perceptions. Professionals will often articulate assessment of place through discursive consciousness, that is they disclose their methods and judgments through a rational articulation (a discourse). Non-professionals tend to interact with, and assess, their urban surroundings through practical consciousness, that is they employ their stock of unarticulated knowledge and past experiences to reach individual and personal conclusions. As these personal evaluations are difficult to rationalize (and individuals are under no obligation to have any justification for their own personal judgments), it is necessary to understand these judgments in the context of each unique individual. This paper proposes that both forms of evaluation are valid; it can be argued that one's perceptions of place create a '*reality*' for that individual more powerful than the expert-led objective measurements (which may differ significantly). What is therefore required is a better understanding of the role design plays in cycling promotion and activity by exploring both the *objective* and *subjective*, only by taking this holistic approach can a full picture be uncovered. Our approach seeks to investigate both cyclists' perceptions as individuals, alongside the assessment of design professionals.

Firstly, an urban design audit will be conducted across a range of sites in Reading, England, and Cardiff, Wales. The sites have been selected to provide a wide variety of urban environments in which cycling can, or does currently, occur. This audit will be 'expert-led', applying a range of professionals from disciplines including architecture, urban design, landscape architecture, and planning. Our approach will be to assess each of the selected sites based upon criteria developed and adapted from Ewing et al. (2013) (see Table 3). These criteria will provide an initial template for analyzing and evaluating the sites regarding the provision of a quality cycling environment, with a particular focus on older users. Alongside this will be a series of mobile interviews with older cyclists (non-expert), who will cycle through the selected sites being measured for a range of variables including EEG, soundscape and sonar proximity detection. They will also be fitted with eye-tracking glasses that incorporate technology that allows the researcher to record where the cyclist is focusing their attention, mapping the key elements and physical features of the built environment that participants engage with as they cycle. Follow up interviews are conducted to ascertain personal perceptions and judgments that they make on the ride regarding the (un)supportive features of the physical environment.

Table 3: Urban design audit criteria – Adapted and developed from Ewing et al. (2013)

Audit Quality Criteria	Descriptors
Imageability	Capturing attention / sense of place / distinct / memorable / vernacular architecture
Legibility	Spatial understanding and ease of navigation / sense of orientation
Enclosure	Streets / definition through buildings, walls, trees / heights, widths and proportions
Human Scale	Size / articulation of physical elements in relation to humans / building and street detail
Transparency	Degree to which people see and perceive what lies beyond / human activity
Linkage	Physical and visual connection from building to street
Complexity	Visual richness of a place – architectural / landscape / streets / signage / human activity
Coherence	Visual order – consistency in scale, character and arrangement
Tidiness	Condition and cleanliness of a place / well maintained
Cycle Scale	The ‘ <i>forgotten middle</i> ’ – unique characteristics of cyclists – height / speed / skill diversity

6. Conclusions

“More research is needed to expand the understanding of aspects of neighbourhood environments influencing the quality and quantity of outdoor activities and consequently people’s health status” (Sugiyama and Ward Thompson, 2007, p174).

Any study of cycling must attempt to innovate beyond the obvious, beyond a previous obsession only on infrastructure such as junctions, cycle lanes, and issues of safety. While these are all vital issues, they have been researched and discussed at length and there is now some consensus about the range of technical ‘solutions’ that exist and are able, to varying degrees, to facilitate safe cycling. In this paper, we have argued that what is needed now is a more collaborative approach across various fields, including health, transport planning and engineering, that recognises the potential of urban design in bringing together extant discussions surrounding levels of physical activity, features of the built environment, and individual perceptions. This entails building an understanding of function (complete cycling network); morphology (buildings and landscape define space at scale of cycle); perception (detailed design is cycle scaled as well as human scaled); social issues (clusters of cyclists / interaction); the visual/aesthetic (balance, complexity and diversity with the need to understand environments at the cyclists speed/height); and time (plan for evolution of facilities; different seasons; adaption and redesigns) (Forsyth and Krizek, 2011).

Professionals such as transport planners, urban designers, and public health specialists must collaborate not only to accomplish their individual targets, but to create a balanced environment that promotes active transport and improves the health of communities (Giles-Corti, 2006). Interventions such as Transport for London’s Transport

Action Plan ‘*Improving the Health of Londoners*’ (TfL, 2014), which recognises transport as a critical factor in both good and poor health in the city, indicates things are moving in the right direction. However, for collaborations to be successful in action, professionals, as well as policy-makers and governments, need to recognise the high levels of ambition and commitment required if this kind of place-making is to be achieved (Sallis et al., 2004). This collaborative approach to planning and design is, according to Giles-Corti (2006) “*essential to avoid piecemeal development*” (p364) and will need to be supported by a research agenda addressing issues of quality, wellbeing and health across disciplines (Sugiyama and Ward Thompson, 2007). This paper champions the currently neglected and undeveloped arena of urban design, but other disciplines must share a common vision if the realities of our built environment are to change people’s health, wellbeing and quality of life through exercises such as cycling. It is in the targeting of these arenas that future research can equip professionals and policy makers across health, design, and planning, to have proper consideration for modifying places and the built environment to create more livable communities and promote active and healthier lifestyles into older age (Li et al., 2005).

‘cycleBOOM’ is a research study that aims to provide the discipline of urban design with a reimagining of its traditional core principles, centred upon the perspectives of cyclists. This reimagining will allow these principles to be redefined and rearticulated to include the unique viewpoint of cycling in design discussions and implementation, raising the profile of cyclists to a level already enjoyed by pedestrians and motorists. Our approach is to not only better understand how we can measure quality in the built environment related specifically to cycling, but to engage with cyclists, and potential cyclists, to give their perceptions a voice. Recognizing them as the ‘*forgotten middle*’ within urban design, beginning the journey to change this preconception, and ultimately influence future designs and research.

Future studies require a quality and clarity of measures and methods that are critical to understanding potential connections of urban environment features with activities such as cycling (Brownson et al., 2009). In outlining our methodology for better understanding urban design features from a cyclists’ perspective, we have made a contribution to this but much more needs to be done. As this paper has shown, a cyclist moves at a different speed, occupies a different space, views and engages with the built environment from a different height to both motorists and pedestrians. It remains to be seen whether urban design can rise to the challenge and design sites that recognize and cater for all three perspectives, but we would argue that, if the goal is to create active and sustainable cities, it must. By doing so, urban design has the opportunity to not only provide a more enjoyable environment for cyclists, but also improve the health of the population who take up this option, and, moreover, impact positively on the wellbeing of the wider urban community.

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References

- Azmin-Fouladi, N., Evans, G., Porta, S., Thwaites, K., Romice, O. & Greaves, M., 2007. ‘Accessibility and user needs in transport: street audit toolkit.’ *Urban Sustainability through Environmental Design: Approaches to Time, People, and Place Responsive Urban Spaces*, 112.
- Ball, K., Bauman, A., Leslie, E. & Owen, N., 2001. ‘Perceived environmental aesthetics and convenience and company are associated with walking for exercise among Australian adults.’ *Preventative medicine*, 33, 434-440.
- Barton, H., Grant, M. & Guise, R., 2002. ‘*Shaping neighbourhoods for health, sustainability and vitality*.’ Routledge, London.
- Berke, E. M., Koepsell, T. D., Moudon, A. V., Hoskins, R. E. & Larson, E. B., 2007. ‘Association of the built environment with physical activity

and obesity in older persons.' *American journal of public health*, 97, 486-492.

Bertera, E. M., 2003. 'Physical activity and social network contacts in community dwelling older adults'. *Activities, Adaptation & Aging*, 27, 113-127.

Blanco, H., Alberti, M., Forsyth, A., Krizek, K. J., Rodríguez, D. A., Talen, E. & Ellis, C., 2009. 'Hot, congested, crowded and diverse: Emerging research agendas in planning.' *Progress in Planning*, 71, 153-205.

Boarnet, M. G. & Crane, R., 2001. '*Travel by design the influence of urban form on travel.*' Oxford University Press, Oxford.

Bonaiuto, M., 2004. 'Residential satisfaction and perceived urban quality.' *Encyclopedia of applied psychology*, 3, 267-272.

Booth, M. L., Owen, N., Bauman, A., Clavisi, O. & Leslie, E., 2000. 'Social-cognitive and perceived environment influences associated with physical activity in older Australians'. *Preventive medicine*, 31, 15-22.

Borst, H. C., De Vries, S. I., Graham, J., Van Dongen, J. E., Bakker, I. & Miedema, H. M., 2009. 'Influence of environmental street characteristics on walking route choice of elderly people'. *Journal of Environmental Psychology*, 29, 477-484.

Borst, H. C., Miedema, H. M., De Vries, S. I., Graham, J. & Van Dongen, J. E., 2008. 'Relationships between street characteristics and perceived attractiveness for walking reported by elderly people'. *Journal of Environmental Psychology*, 28, 353-361.

Bortz, W. M., 1982. 'Disuse and aging'. *Jama*, 248, 1203-1208.

Bowling, A., Gabriel, Z., Dykes, J., Dowding, L. M., Evans, O., Fleissig, A., Banister, D. & Sutton, S., 2003. 'Let's ask them: a national survey of definitions of quality of life and its enhancement among people aged 65 and over'. *The International Journal of Aging and Human Development*, 56, 269-306.

Brownson, R. C., Hoehner, C. M., Day, K., Forsyth, A. & Sallis, J. F., 2009. 'Measuring the built environment for physical activity: state of the science'. *American journal of preventive medicine*, 36, S99-S123. e12.

Bull, F., Milligan, R., Rosenberg, M. & Macgowan, H., 2000. 'Physical activity levels of Western Australian adults 1999'. *Published by the Health Department of Western Australia and Sport and Recreation Way2Go, Western Australian Government, Perth: Western Australia.*

Burgoyne, L. N., Woods, C., Coleman, R. & Perry, I. J., 2008. 'Neighbourhood perceptions of physical activity: a qualitative study'. *BMC Public Health*, 8, 101.

Carnegie, M., Bauman, A., Marshall, A., Mohsin, M., Westley-Wise, V. & Booth, M., 2002. 'Perceptions of the physical environment, stage of change for physical activity, and walking among Australian adults'. *Research quarterly for exercise and sport*, 73, 146-155.

Cervero, R. & Kockelman, K., 1997. 'Travel demand and the 3Ds: density, diversity, and design'. *Transportation Research Part D: Transport and Environment*, 2, 199-219.

Coleman, A., 1985. '*Utopia on trial: Vision and reality in planned housing.*' Shipman, London.

Dannenberg, A. L., Jackson, R. J., Frumkin, H., Schieber, R. A., Pratt, M., Kochützky, C. & Tilson, H. H., 2003. 'The impact of community design and land-use choices on public health: a scientific research agenda'. *American journal of public health*, 93, 1500-1508.

De Bourdeaudhuij, I., Sallis, J. F. & Saelens, B. E., 2003. 'Environmental correlates of physical activity in a sample of Belgian adults'. *American journal of health promotion*, 18, 83-92.

De Geus, B., De Bourdeaudhuij, I., Jannes, C. & Meeusen, R., 2008. 'Psychosocial and environmental factors associated with cycling for transport among a working population'. *Health Educ Res*, 23, 697-708.

Ding, D. & Gebel, K., 2012.. 'Built environment, physical activity, and obesity: What have we learned from reviewing the literature?' *Health & Place*, 18, 100-105.

Ewing, R., Clemente, O., Neckerman, K. M., Purciel-Hill, M., Quinn, J. W. & Rundle, A., 2013. '*Measuring Urban Design: Metrics for livable places.*' Island Press, USA.

Ewing, R. & Handy, S., 2009. 'Measuring the Unmeasurable: Urban Design Qualities Related to Walkability'. *Journal of Urban Design*, 14, 65-

84.

Ewing, R., Handy, S., Brownson, R. C., Clemente, O. & Winston, E., 2006. 'Identifying and measuring urban design qualities related to walkability'. *Journal of Physical Activity and Health*, 1, 223-240.

Forsyth, A., Hearst, M., Oakes, J. M. & Schmitz, K. H., 2008. 'Design and destinations: factors influencing walking and total physical activity'. *Urban Studies*, 45, 1973-1996.

Forsyth, A. & Krizek, K., 2011. 'Urban Design: Is there a Distinctive View from the Bicycle?' *Journal of Urban Design*, 16, 531-549.

Forsyth, A., Michael Oakes, J., Lee, B. & Schmitz, K. H., 2009. 'The built environment, walking, and physical activity: Is the environment more important to some people than others?' *Transportation Research Part D: Transport and Environment*, 14, 42-49.

Foster, C., Hillsdon, M. & Thorogood, M., 2004. 'Environmental perceptions and walking in English adults'. *Journal of epidemiology and community health*, 58, 924- 928.

Frank, L., Engelke, P. & Schmid, T., 2003. '*Health and community design: The impact of the built environment on physical activity*', Island Press, USA.

Frumkin, H., 2002. 'Urban sprawl and public health'. *Public health reports*, 117, 201.

Gale, C. R., Dennison, E. M., Cooper, C. & Sayer, A. A., 2011. 'Neighbourhood environment and positive mental health in older people: the Hertfordshire Cohort Study'. *Health & place*, 17, 867-874.

Gallagher, N. A., Gretebeck, K. A., Robinson, J. C., Torres, E. R., Murphy, S. L. & Martyn, K. K., 2010. 'Neighborhood factors relevant for walking in older, urban, African American adults'. *Journal of aging and physical activity*, 18, 99.

Gehl, J. & Svarre, B., 2013. '*How to study public life*'. Island press. Washington.

Gidlow, C., Cochrane, T., Davey, R. C., Smith, G. & Fairburn, J., 2010. 'Relative importance of physical and social aspects of perceived neighbourhood environment for self-reported health'. *Preventive medicine*, 51, 157-163.

Giles-Corti, B., 2006. 'People or places: what should be the target?' *Journal of Science and Medicine in Sport*, 9, 357-366.

Glass, T. A. & Balfour, J. L., 2003. 'Neighborhoods, aging, and functional limitations'. *Neighborhoods and health*, 303-334.

Glass, T. A., De Leon, C. F. M., Bassuk, S. S. & Berkman, L. F., 2006. 'Social engagement and depressive symptoms in late life longitudinal findings'. *Journal of Aging and Health*, 18, 604-628.

Greenberg, M. & Crossney, K., 2007. 'Perceived neighborhood quality in the United States: Measuring outdoor, housing and jurisdictional influences'. *Socio-Economic Planning Sciences*, 41, 181-194.

Hallman, H. W., 1984. '*Neighborhoods: Their place in urban life*'. Sage Publications Beverly Hills, CA.

Handy, S. L., Boarnet, M. G., Ewing, R. & Killingsworth, R. E., 2002. 'How the built environment affects physical activity: views from urban planning'. *American journal of preventive medicine*, 23, 64-73.

Hartig, T., Evans, G. W., Jamner, L. D., Davis, D. S. & Gärling, T., 2003. 'Tracking restoration in natural and urban field settings'. *Journal of environmental psychology*, 23, 109-123.

Hoehner, C. M., Brennan Ramirez, L. K., Elliott, M. B., Handy, S. L. & Brownson, R. C., 2005. 'Perceived and objective environmental measures and physical activity among urban adults'. *American journal of preventive medicine*, 28, 105-116.

Humpel, N., Owen, N. & Leslie, E., 2002. 'Environmental factors associated with adult's participation in physical activity: A review'. *American Journal of Preventative Medicine*, 22, 188-199.

Imrie, R., 2001. 'Barrierred and bounded places and the spatialities of disability'. *Urban Studies*, 38, 2, 231-237.

Jenks, M. & Dempsey, N., 2007. 'Defining the neighbourhood: challenges for empirical research'. *Town Planning Review*, 78, 153-177.

- Kaplan, S., 1995. 'The restorative benefits of nature: Toward an integrative framework'. *Journal of environmental psychology*, 15, 169-182.
- King, A. C., Jeffery, R. W., Fridinger, F., Dusenbury, L., Provenance, S., Hedlund, S. A. & Spangler, K., 1995. 'Environmental and policy approaches to cardiovascular disease prevention through physical activity: issues and opportunities'. *Health Education & Behavior*, 22, 499-511.
- Lawton, M. P. & Nahemow, L., 1973. 'Ecology and the aging process'. In C. Eisdorfer & M. P. Lawton (Eds.), *The psychology of adult development and aging*. (pp. 619-674). Washington DC: American Psychological Association.
- Li, F., Fisher, K. J., Brownson, R. C. & Bosworth, M., 2005. 'Multilevel modelling of built environment characteristics related to neighbourhood walking activity in older adults'. *Journal of epidemiology and community health*, 59, 558-564.
- Lopez, R. P., 2012. *The Built Environment and Public Health*. Jossey-Bass, Wiley.
- Lovasi, G., Moudon, A., Pearson, A., Hurvitz, P., Larson, E., Siscovick, D., Berke, E., Lumley, T. & Psaty, B., 2008. 'Using built environment characteristics to predict walking for exercise'. *International Journal of Health Geographics*, 7, 10.
- Maller, C., Townsend, M., Pryor, A., Brown, P. & St Leger, L., 2006. 'Healthy nature healthy people: contact with nature as an upstream health promotion intervention for populations'. *Health promotion international*, 21, 45-54.
- Michael, Y. L., Green, M. K. & Farquhar, S. A., 2006. 'Neighborhood design and active aging'. *Health & place*, 12, 734-740.
- Moser, G., 2009. 'Quality of life and sustainability: Toward person–environment congruity'. *Journal of Environmental Psychology*, 29, 351-357.
- Moudon, A. V., Lee, C., Cheadle, A. D., Collier, C. W., Johnson, D., Schmid, T. L. & Weather, R. D., 2005. 'Cycling and the built environment, a US perspective'. *Transportation Research Part D: Transport and Environment*, 10, 245-261.
- Nasar, J. L., 1994. 'Urban design aesthetics the evaluative qualities of building exteriors'. *Environment and behavior*, 26, 377-401.
- Nasar, J. L., 2008. 'Assessing perceptions of environments for active living'. *American journal of preventive medicine*, 34, 357-363.
- NYC (New York City), 2010. *Active design guidelines: Promoting physical activity and health in design*. City of New York. NY.
- Owen, N., Humpel, N., Leslie, E., Bauman, A. & Sallis, J. F., 2004. 'Understanding environmental influences on walking; Review and research agenda'. *American Journal for Preventative Medicine*, 27, 67-76.
- Patterson, P. K. & Chapman, N. J., 2004. 'Urban form and older residents' service use, walking, driving, quality of life, and neighborhood satisfaction'. *American Journal of Health Promotion*, 19, 45-52.
- Pikora, T. J., Giles-Corti, B., Knuiaman, M. W., Bull, F. C., Jamrozik, K. & Donovan, R. J., 2006. 'Neighborhood environmental factors correlated with walking near home: using SPACES'. *Medicine and Science in Sports and Exercise*, 38, 708- 714.
- Pooley, C., Jones, T., Tight, M., Horton, D., Scheldeman, G., Mullen, C., Jopson, A. & Strano, E., 2013. *Promoting walking and cycling: new perspectives on sustainable travel*. Policy Press, Bristol.
- Pooley, C., Tight, M., Jones, T., Horton, D., Scheldman, G., Jopson, A., Mullen, C., Chilsholm, A., Strano, E. & Constantine, S., 2011. *Understanding Walking and Cycling: Summary of Key Findings and Recommendations*. Lancaster University.
- Pucher, P., Buehler, R., 2012. *City Cycling*. MIT Press, Cambridge.
- Rowley, A., 1994. 'Definitions of urban design: the nature and concerns of urban design'. *Planning Practice and Research*, 9, 179-197.
- Saelens, B. E., Sallis, J. F. & Frank, L. D., 2003. 'Environmental Correlates of Walking and Cycling: Findings from the Transportation, Urban Design, and Planning Literatures'. *Environmental and Physical Activity*, 25, 80-91.
- Sallis, J. F., Frank, L. D., Saelens, B. E. & Kraft, M. K., 2004. 'Active transportation and physical activity: opportunities for collaboration on transportation and public health research'. *Transportation Research Part A: Policy and Practice*, 38, 249-268.
- Sarmiento, O. L., Schmid, T. L., Parra, D. C., Díaz-Del-Castillo, A., Gómez, L. F., Pratt, M., Jacoby, E., Pinzón, J. D. & Duperly, J., 2010. 'Quality of life, physical activity, and built environment characteristics among Colombian adults'. *Journal of physical activity & health*, 7.

- Shaw, B. A., Krause, N., Liang, J. & Bennett, J., 2007. 'Tracking changes in social relations throughout late life'. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 62, S90-S99.
- Stronegger, W. J., Titze, S. & Oja, P., 2010. 'Perceived characteristics of the neighborhood and its association with physical activity behavior and self-rated health'. *Health & place*, 16, 736-743.
- Sugiyama, T. & Ward Thompson, C., 2007. 'Measuring the quality of the outdoor environment relevant to older people's lives'. *Open space: people space*, 153-162.
- Sugiyama, T. & Ward Thompson, C., 2008. 'Associations between characteristics of neighbourhood open space and older people's walking'. *Urban Forestry & Urban Greening*, 7, 41-51.
- Tilahun, N. Y., Levinson, D. M. & Krizek, K. J., 2007. 'Trails, lanes, or traffic: Valuing bicycle facilities with an adaptive stated preference survey'. *Transportation Research Part A: Policy and Practice*, 41, 287-301.
- Titze, S., Stronegger, W. J., Janschitz, S. & Oja, P., 2008. 'Association of built- environment, social-environment and personal factors with bicycling as a mode of transportation among Austrian city dwellers'. *Preventive Medicine*, 47, 252-259.
- Townshend, T. & Lake, A. A., 2009. 'Obesogenic urban form: theory, policy and practice'. *Health & place*, 15, 909-916.
- TfL (Transport For London). (2014) '*Improving the Health of Londoners: A transport action plan*'. Transport for London. London.
- Tranter, R., Slater, R. & Vaughan, N., 1991. 'Barriers to mobility: physically-disabled and frail elderly people in their local outdoor environment'. *International Journal of Rehabilitation Research*, 14, 303-312.
- Troped, P. J., Saunders, R. P., Pate, R. R., Reininger, B., Ureda, J. R. & Thompson, S. J., 2001. 'Associations between self-reported and objective physical environmental factors and use of a community rail-trail'. *Prev Med*, 32, 191-200.
- Van Cauwenberg, J., De Bourdeaudhuij, I., De Meester, F., Van Dyck, D., Salmon, J., Clarys, P. & Deforche, B., 2011. 'Relationship between the physical environment and physical activity in older adults: a systematic review'. *Health & place*, 17, 458-469.
- Van Kamp, I., Leidelmeijer, K., Marsman, G. & De Hollander, A., 2003. 'Urban environmental quality and human well-being: Towards a conceptual framework and demarcation of concepts; a literature study'. *Landscape and Urban Planning*, 65, 5-18.
- Van Lenthe, F., Brug, J. & Mackenbach, J., 2005. 'Neighbourhood inequalities in physical inactivity: the role of neighbourhood attractiveness, proximity to local facilities and safety in the Netherlands'. *Social science & medicine*, 60, 763-775.
- Wang, Z. & Lee, C., 2010. 'Site and neighborhood environments for walking among older adults'. *Health Place*, 16, 1268-79.
- Wardman, M., Tight, M. & Page, M., 2007. 'Factors influencing the propensity to cycle to work'. *Transportation Research Part A: Policy and Practice*, 41, 339-350.
- Wendel - Vos, W., Droomers, M., Kremers, S., Brug, J. & Van Lenthe, F., 2007. 'Potential environmental determinants of physical activity in adults: a systematic review'. *Obesity reviews*, 8, 425-440.
- Winters, M., Babul, S., Becker, H. J., Brubacher, J. R., Chipman, M., Cripton, P., Cusimano, M. D., Friedman, S. M., Harris, M. A., Hunte, G., Monro, M., Reynolds, C. C., Shen, H., Teshke, K., 2012. 'Safe cycling: How do risk perceptions compare with observed risk?' *Canadian Journal of Public Health*, 103, 9(suppl3), p.42-7.
- Yen, I. H., Michael, Y. L. & Perdue, L., 2009. 'Neighborhood environment in studies of health of older adults: a systematic review'. *American journal of preventive medicine*, 37, 455-463.