IAAPE - Pedestrian accessibility and attractiveness assessment tool when planning for walkability

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Every trip begins and ends with a walking trip, and everyone is a pedestrian at least for a part of his journey. Walking has been considered the "foundation of the sustainable city" providing social, environmental and economic benefits, often being the only way many people can access everyday activities. Walking also brings life to streets and livable streets contribute to safer urban environments. The contribute of walking to community safety, accessibility and social inclusion has emerged as a particular challenge to the design of the urban environment, as "over the past century pedestrian access has declined steadily in most cities" (Abley and Turner, 2011; Evans, 2009; Forsyth and Southworth, 2008; Krambeck and Shah, 2006).

Keywords: walkability, pedestrians, built environment, multicriteria assessment, indicators

1 Introduction

Every trip begins and ends with a walking trip, and everyone is a pedestrian at least for a part of his journey. Walking has been considered the “foundation of the sustainable city” providing social, environmental and economic benefits, often being the only way many people can access everyday activities. Walking also brings life to streets and livable streets contribute to safer urban environments. The contributions of walking to community safety, accessibility and social inclusion has emerged as a particular challenge to the design of the urban environment, as “over the past century pedestrian access has declined steadily in most cities” (Abley and Turner, 2011; Evans, 2009; Forsyth and Southworth, 2008; Krambeck and Shah, 2006).
With such associated benefits, one of the most critical questions to be asked is how to encourage more people to walk more. This question has been particularly addressed to urban planners in terms of the contribution of the built environment in encouraging and promoting walking. From one perspective, the relation of the built environment with walking behavior has been mostly intuitive, as there has been little scientific evidence in supporting the extent and intensity of such relation (Park, 2008). From another point of view, research has provided sufficient evidence on the link between built environment and walking (Handy, 2005), and focus should be set in identifying and assessing the built environment attributes that make up a pedestrian friendly environment.

Walkability has been recently introduced as a concept that translates “the extent to which characteristics of the built environment and land use may or may not be conductive to residents in the area walking for either leisure, exercise or recreation, to access services, or to travel to work” (Leslie et al., 2007), or in simpler terms, the extent to which the urban environment is pedestrian friendly (Abley and Turner, 2011). By assessing (or measuring) it, planning professionals may be able to address the quality of the pedestrian environment, which may facilitate the progress towards more integrated, appealing and walking conductive cities.

The aim of this work is to find suitable pedestrian accessibility and attractiveness indicators for walkability assessment, in order to support more objective and comprehensive planning strategies and interventions. Pedestrian accessibility has now been fairly extensively addressed by the literature. However, it is not only the existence of an accessible environment that makes pedestrians use it. Making it attractive plays a fundamental role. Hence, measuring the quality of urban walkable spaces adds on an attractiveness dimension to pedestrian accessibility analysis, which enriches the modeling and evaluation of more urban walkable environments.

Many assessment models and indicators have been put forward in the literature coming from different fields of expertise: urban planners, transportations engineers, social sciences and public health. Several issues and concerns can be drawn from the various perspectives, namely that walkability cannot be definable as a single entity. The built environment factors that affect walking likely differ according to other factors, being the user itself (if young, old, male, female, fit, unfit), the walking purpose (transportation, recreation), the urban context where walking takes place and by other environmental and cultural variables. Although many models refer the importance of such issues, integrated and structured analysis that bring together these concerns are still lacking.

A walkability assessment framework was developed with multicriteria decision analysis (MCDA) and GIS network analysis, able to address different scales (city, neighborhood and street levels), different pedestrian groups (adults, the elderly, children and disabled pedestrians) and different trip purposes (practical/commuting, leisure) (Cambra, 2012).

This paper focuses on the structuring phase of the assessment framework, where the selection of built environmental indicators takes place, and on the scoring phase, where the relative importance of the urban factors is weighted.

In particular, the structuring phase consisted in guided interviews with an expert panel and a stakeholder session with representatives of 4 main pedestrian groups – adults, elderly, children and reduced mobility pedestrians. The scoring phase was also took place during this session with the aim to: 1) understand if the concerns differed amongst the expert and stakeholders perspectives; 2)
understand if distinct user groups stated different environmental factors as the most important; 3) define a set of assessment indicators per user groups; 4) address the relative importance of each selected factor by means of weighting; 5) understand if the relative importance changed with the trip purpose; and 6) obtain solid basis for a walkability assessment framework.

The results show clear differences in the perceived importance of pedestrian environment concerns, varying with users perspectives and their trip purpose.

2 Literature review: Assessing Walkability

Walking has been often considered as the “forgotten mode” of transport, but is now gaining attention as a key factor in the promotion of healthier, environmental friendly and socially active communities. Various fields of research have pointed out the benefits of walking for the individual, associated with physical activity and related to obesity, cardiovascular and mental benefits; and for communities and cities, associated with social interaction, safer environments, less energy consumption and gas emissions, or, in simpler terms, more livable urban spaces (Lee and Talen, 2014; Abley and Turner, 2011; Frank et al., 2005).

With proven benefits, and with sufficient evidence on the influence of built environment factors in encouraging and promoting walking, there has been an increased engagement from researchers and from authorities and policy makers in addressing the conditions and the quality of the pedestrian environment. Many measures have been developed in the past decade to provide an objective answer to the question “how walkable is my street/ neighbourhood/ city”. These measures are the focus of walkability assessment research (Cambra, 2012).

Walking, being a simple way of getting around and with little need for special infrastructure has lagged behind the other modes in terms of research. Other modes of transport, especially the private motor vehicle, have undergone significant study over the last decades and have a high degree of measurability. Furthermore, despite having emerged as a popular topic in forums related to transportation and urban planning there has been a generalized lack of consensus on the meaning of walkability. A wide range of actors have been involved in pursuing the evaluation of the relations between the urban environment and the pedestrian behavior, and all have a different definition on how to measure walkability (Lo, 2009).

If walking is a simple way of getting around, addressing the environmental factors that encourage or deter walking has not been found to be that simple nor consensual. The complexity of relations between the built environment factors and walking behavior, the role of individual perceptions of the built environment, the importance of attitudes, lifestyle and transportation alternatives (Handy, 2005; Schmid, 2006) lead to an intricate frame of reciprocal influences that researchers are just starting to untangle.

Albeit the impressive developments in walkability measurement studies, some practical issues are found to remain, namely on the 1) dispersion of concepts and measurement methodologies, 2) scale of analysis, 3) urban context and origin of studies, 4) multiplicity of indicators used for assessment and 5) model validation (Cambra, 2012).
Being a multidisciplinary concern and evolving researchers from various fields (public health, social sciences, transport engineering, urban planning and architecture), a variety of walkability assessment methods has been developed, sometimes, focusing particular concerns from each field. Therefore many tools have emerged, during the past few years, for measuring the quality of the built environment, or the walkability of neighborhood designs.

The assessment of the walking environment has been done using various methods, which include audit tools; checklists; inventories; level-of-service scales; surveys; questionnaires and indices. Although they may differ in their implementation these methods have two major types of outcome: either a single number that categorizes the environment as high vs. low suitability for walking; or the measure of the amount of features that support or hinder walking. Such examples have shown that this measurement can be performed quantitatively or qualitatively. Moreover, there have been techniques developed to address to different scales, from the neighborhood area to the street segments and even intersections (Maghelal and Capp, 2011; Ewing and Handy, 2009; Leslie et al., 2007).

One issue that has been found to be common to most tools, independent of being quantitative or qualitative and of the analysis scale, is the dispersion and unclear structuring of the evaluation criteria, resulting in the use of a simple additive model to simply add up scores from randomly selected evaluation criteria (Park et al., 2014).

Selecting the "most important" environmental factors and their relative importance has been pointed as a key issue common to most studies, as there is still the lack of empirical evidence to provide the answer. Literature reviews of the existing walkability indices point to dozens if not hundreds of attributes suitable to be included in the pedestrian environment assessment, with little supporting scientific evidence to decide the importance of each walkability indicator relative to others (Park et al., 2014; Cambra, 2012; Weinberger and Sweet, 2012; Maghelal and Capp, 2011; Evans 2009; Dauden et al., 2009; Park, 2008; Soltani and Allan, 2005).

In order to facilitate the structuring and selection of concerns to address and indicators to perform the measures, there have been solid contributions to the categorization of environmental factors related to walking. From these, the most well known is perhaps the 3D’s layout – Density, Diversity and Design, by Cervero and Kockelman (1997), that was expanded later to a 5D’s arrangement by adding Destination accessibility and Distance to transit (Ewing et al., 2013).

Similar structures have been developed, aggregating key concerns with some commonalities in configuration and some variiances in the naming convention. Such examples, reviewed by Gherke (2012), include the Irvine-Minnesota Inventory, with its Accessibility, Pleasurability and Safety (perceived safety from traffic and from crime); the Systematic Pedestrian and Cycling Environment Scale (SPACES) with its Functional, Safety, Aesthetics, Destination and Subjective elements; the Pedestrian Environmental Data Scan (PEDS) with its Environment, Pedestrian Facility, Road Attributes and Walking environment elements, or the proposed STEPP mnemonic which stands for Safety, Track, Environment, Population and Purpose (Gehrke, 2012).

To our understanding, there is yet another classification scheme that provides a more extensive grip of the walkability concept and to the notion of a "pedestrian friendly" environment. That classification is known as the 5C’s layout, originally coined by a Transport for London
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workgroup (Pharoah, 2005), which considers and prioritizes pedestrians’ needs, and has been widely adopted to the present (COST 358, 2010). According to this scheme, a pedestrian friendly environment has to be Connected, Convenient, Comfortable, Convivial and Conspicuous.

However, given the particular importance of factors related to 1) pedestrian safety from traffic and traffic impacts on the public space and 2) policy level pedestrian promotion, recent research has proposed two additional dimensions to be included in the scheme, forming the Coexistence and Commitment layers, and setting up the 7C’s layout, under which all reported built environment factors can be filed and structured (Cambra, 2012). As with other classification schemes, some of the dimensions (or key-concerns) have a fairly straightforward understanding whilst others overlap (Ewing et al., 2013), with an overall positive contribution in structuring and operationalizing the walkability assessment framework.

Other practical issues that were reported in walkability measurement tools relate to the scale of the analysis, purpose of walking journey and pedestrian type. Various researchers have worked on ways to overcome these issues, producing supporting evidence that:

1) built environment factors have a different importance at a micro or a macro level, being the micro level related to the street scale and therefore with more experiential, qualitative attributes (Lee and Talen, 2014; Park, 2008);

2) the purpose of a trip makes a difference on the role played by some built environmental factors, being therefore crucial to distinguish between “utilitarian” walking (e.g. walking to work, school) and “recreational” walking (e.g. strolling) (Park et al., 2014; Lee and Talen, 2014; Cao et al., 2006);

3) Different user groups (e.g. adults, children, elderly or persons with impairment) have different quality needs and therefore the relative importance of built environment features may also be different (COST 358, 2010).

Moreover, it now seems evident that walkability measures cannot be seen as “one size fits all” tools, but varies with trip purpose, pedestrian group and are subject to local conditions, being difficult to adopt results and tools originated in very different urban contexts (Lee and Talen, 2014; Guo and Loo, 2013; Weinberger and Sweet, 2012; Manaugh and El-Geneidy, 2011). In broad terms, the European urban context differs greatly from the US, Canada and Australian environments, which have taken the lead in developing walkability tools, with Scottish researchers identifying 18 relevant items whose pertinence was higher in Northern Europe (e.g. public transport, streetscape) (Lee and Talen, 2014). Similar findings are expressed in studies developed in Southern Europe (Dauden et al., 2009) or South Africa, (Albers et al., 2010).

Based on the 7C’s layout and on the cited issues, a walkability assessment framework has been developed, able to address different scales (city, neighbourhood and street), different pedestrian groups (adults, elderlies, children and impaired pedestrians) and different trip purposes (transportation, leisure). Such framework was developed to support and be used by local authorities and urban planning practitioners. The term “local” here may be also applied to the context, as the
framework was developed to meet the Portuguese urban context. The process of structuring and weighting the factors for the local context is described in the next section.

3 Process description

This section focuses on the structuring phase of the walkability assessment framework, where the selection of environmental indicators takes place, and on the scoring phase, where the relative importance of the urban factors is weighted.

Given that the agreement on the important factors contributing to walkability are still very much in contention (Clifton et al., 2007), and that perceptions play a major role in influencing people’s walking behavior but are difficult to address objectively, several studies point out the use of a combination of comprehensive, objective data (with the generalized use of GIS), with observational urban environment analysis, combined with user consultation on needs, aspirations and perceptions (Batista e Silva et al., 2013; Evans, 2009; Ewing and Handy, 2009).

Surely empirical research is required to identify which factors are more important (Pikora et al., 2003) but current limitations and challenges related to this subject can be in a way bypassed with expert panel consultations, public questionnaires and stakeholder’s sessions. These processes can be of a more subjective nature, but as noted by Batista e Silva et al. (2013), “objectivity and subjectivity are complementary issues that planning practice should deal with, for better and for worse”.

In general terms, the application of questionnaires has been a pragmatic approach in assessing public perception (Batista e Silva et al., 2013), and asking people about their perceptions may result in understanding the relative importance of each environmental attribute. But, on the other hand, given that some of the concepts addressed are not familiar to the “average person”, it has been noted that it may not be possible to “simply ask a random sample of street users to rate streetscapes with regard to their ‘legibility’, ‘coherence’ and so on” (Ewing and Handy, 2009).

In order to reach a consensual set of pedestrian environment concerns, one of the frameworks used in the reviewed walkability methodologies is the group framework. In this case, a group of experts has one or several meetings (that could be led by a facilitator as a “post-it” session) in order to find a consensual family of concerns to be assessed, or, in practice, the built environmental factors that are believed to have the most relevant role in walking behavior. Such framework is used, for instance, on the work by the European Cost 358 action – Pedestrian Quality Needs (COST 358, 2010).

Another interesting approach has been conducted by Pikora et al. (2003), in which a framework for walkability assessment was structured with in-depth interviews and a Delphi study with a group of experts (from different backgrounds and research interests) to clarify influential factors on walking and to determine their perceived relative importance (Pikora et al., 2003).

3.1 Structuring phase

The structuring phase of our framework consisted in guided interviews with an expert panel and a stakeholder session with representatives of 4 main pedestrian groups – adults, elderly, children and impaired pedestrians. The scoring phase was also conducted in this session with the aim to
address the relative importance of each selected factor by means of weighting, controlling for user group and trip purpose. This structuring stage has been considered as a fundamental and essential activity on building multicriteria evaluation models by some authors in the field of Multicriteria Decision Analysis (MCDA). Structuring is also said to be considered a “mixture of art and science” and a recursive learning process, deepening knowledge of concerns (Batista e Silva et al., 2013; Bana e Costa and Beinat, 2005).

MCDA literature states that the selection of concerns and indicators should be consensual, exhaustive, non-redundant, and as concise as possible. It should be concise in order to include only the essential in the model; non-redundant in order to avoid double-counting and exhaustive to avoid leaving out important viewpoints. The assessment model should also be concise in order to avoid the common temptation of taking everything into account, generating the “information pollution”, in which the information generated is in such quantity that it cannot be digested by the actors. Accounting for too many criteria is pointed out as a common weakness found in multicriteria analysis (Bana e Costa and Beinat, 2010, 2005).

As noted in the research of Park (2008), the selection of candidates of possible walkability indicators tried to be as inclusive and detailed as possible, to the point when the question arose of how many attributes and how much detail could be measured without losing objectivity.

3.2 Scoring phase
With a set and consensual table of concerns the following stage consisted on the estimation of the relative importance of each concern, assigning weights to the built environment factors. There are several methodologies that can be used to aid this process, and specific applications for this purpose, such as MACBETH and 1000Minds, can be found freely available.

As observed in reviewed walkability methodologies, the weighting of the factors has either not been considered or it has been performed without solid basis and justifications. The current degree of empirical knowledge on this matter has been proven insufficient to state the relative importance of the individual environmental factors regarding walking behavior.

3 The experiment: how we did it
3.1 Phase 1, stage 1) Expert meetings
A comprehensive literature review of qualitative and quantitative walkability assessment methods was conducted, demonstrating a wide range of potential indicators for built environment factors that may influence walking. This review collected approximately 200 items (concerns related to characteristics of the built environment or assignable to it), followed by a screening process to clear obvious redundancies. These factors were aggregated in families of concerns and categorized under the 7Cs layout, that is to say each concern would relate to a key qualities of a pedestrian friendly environment: Connectivity; Convenience; Comfort, Conviviality, Conspicuousness, Coexistence and Commitment. The categorization was straightforward for most items, albeit a natural overlapping of the key qualities, or dimensions.
The validation of the concerns and its categorization was done by conducting a series of semi-structured interviews with local experts from a variety of academic backgrounds and professional experience dealing with walkability-related topics. In these interviews, experts were asked to reckon on each of the 7 C’s: which key concerns would better express each dimension; their agreement on the proposed categorization of concerns; and to suggest additions, deletions or modifications to the listed concerns. In this stage, 14 experts were interviewed, from the fields of social sciences, architecture, urban planning, geography, sociology, psychology, being either academic researchers or practitioners closely related to one of the 4 pedestrian groups – adults, elderly, impaired or children.

This multi-disciplinary feedback contributed to clarify the concerns (and therefore the environmental factors) possibly better suited for the local urban context. It also demonstrated the acknowledgment of the relative importance of the concerns according to the interviewee background, with a same concern being pointed out as “highly important” by some, and deleted from the list by others.

There was a general agreement on the 7Cs layout, with clear consensus on the addition of the “coexistence” and “commitment” dimensions to the existing 5Cs layout, and with diverging interpretations of the “convenience” and “comfort” dimensions, as these two qualities appear to be extremely close. The importance of inclusive design and universal accessibility was also stated, being referred as a matter of network “connectivity” rather than a factor of “convenience”.

A transversal analysis of the 14 interviews allowed to shortlist the main concerns in 5 key concerns for each of the 7Cs. In the majority of cases, there was no solid agreement on which of the concerns would better express the respective dimension, and therefore originate potential indicators for its measurement.

3.2 Phase 1, stage 2) Stakeholders session
The second stage of the structuring phase consisted in a stakeholder session in order to find a fit between expert and community representative’s positions and to select a set of key concerns for the scoring phase. A panel of 17 cross-sectional stakeholders was gathered; representing local authorities, community activism, elderly and impaired individuals, and distinct fields of practice (urban planning, transport, social sciences).

Each stakeholder was assigned a generic play-role (adult, elderly, impaired, child), according to its personal and professional backgrounds. Stakeholders should assume their play-role and provide their responses accordingly. The definitions of the play roles were not too tight – e.g., the adult group presumed an active adult person; an elderly presumed an active senior person; the impaired group presumed a person with a temporary or permanent walking impairment, including walking with a baby cart; the children group presumed either a parent’s point of view as well as a child able to walk independently to school, typically between 10-16 years old. In future research, pedestrian groups should be further disaggregated, especially in the cases of elderly and children.

The session took place in a room where 7 posters were displayed, one for each of the 7Cs layout. Each poster showed a detailed definition of the dimension, a brief definition in simpler terms and illustrative examples of urban environments. The shortlist of 5 key concerns was also
displayed, along with potential indicators for its measurement. Color markers (stickers) were given to the participants, according to their play-role.

In a first round, 6 markers per person per poster were distributed; being each one asked to select the most important concerns in each poster. The selection could be made by means of a simple rating scale – 3 markers for the most important, 2 for the second most important and 1 marker for the least important – although participants were free to score the most important concern with 6 markers, or to distribute their markers evenly if they got to a stalemate. Participants were asked to group randomly around the posters, and had limited time to perform the rating, at the end of which they would move to a next poster. The random distribution of participants intended to reduce biased ratings, as people with the same play role could influence each other decisions. At the end of this round, we are able to collect different pedestrian user’s perspectives over the listed concerns and their ratings in order to select the most important concerns for the weighting phase. The marking sheets placed over the posters were retrieved and replaced by blank ones for a second round.

In the second round, participants were asked to roam the posters again, this time rating the overall most important concerns. They were given 28 markers to rate their judgment on the most relevant concerns, being free to rank any set of concerns, from placing all 28 markers in a single concern to placing 1 marker in 28 different concerns. The aim of this round was to check for differences between a conditioned choice (rating concerns in all 7 dimensions) and a free choice, and to check the perceived relative importance of each key quality of the pedestrian environment. Based on the results of the first round, the highest ranked concern was selected for each dimension and for each of the 4 pedestrian groups, resulting in 4 sets of 7 concerns to be used as criteria in the scoring phase. Only the highest ranked concern of each dimension was selected due to operational limitations related to the weighting process.

In the weighing phase, we used of the web application of “1000 Minds” multi-attribute decision analysis tool (www.1000minds.com), which applies the PAPRIKA (Potentially All Pairwise RanKings of all possible Alternatives) methodology to quantify the relative importance of relevant indicators within a particular case (Hansen and Ombler, 2008). This allows, in a straightforward way, to compare criteria trade-offs by means of simple questions of the type “which option is preferable? A or B?”. However, pilot tests revealed interviewees’ dispersion after approximately 30 minutes of questionnaire, with an increase of “they are the same” or “I don’t know” answers. In order to maintain reasonable time limits, the concerns at stake should be strictly limited. Various decision simulations showed that, if considering a basis of 7 criteria, any additional criterion would add several questions more, increasing the response time by one third. Using 10 criteria, for instance, would result in a 1h long questionnaire.

Narrowing the selection of relevant walkability indicators to one key concern for each of the 7Cs was a limitation of our method, and something to explore in future research. Another issue consisted in the cases of tied scores on the highest ranked key concern(s). In these cases, the selected key concern was the one that had been previously selected on the expert interviews.
These issues may introduce some bias to the weighting results, as the weights would probably change if a different key concern would be added. Nonetheless, the main goal of this process was to check for differences in the selection and scoring of pedestrian environment concerns by pedestrian user group and by trip purpose.

3.3 Phase 2, Weighting: stakeholder Delphi session

The second phase of the process consisted in the weighting of the previously selected key concerns, conducted by the same stakeholder panel. We ran a guided Delphi session supported by a web-based decision-making application (1000 Minds). In this session, stakeholders were grouped by play-role at a table, together with a facilitator with a laptop and a large computer screen.

Each facilitator would ask questions to the group and introduce the answers in the software. Each question is typically a trade-off between 2 key concerns, comparing a situation with the highest score on concern A) and lowest score on concern B) vs. a situation with the lowest score on concern A) and highest score on concern B) (conversely), being asked "which of the situations is more pedestrian-friendly". This way, for each question, the panel members were asked to choose one of the 2 options. The panel members should discuss it until agreement was reached. This adaptation of a guided Delphi method allows reaching consensual viewpoints perhaps in a more expedite way than the classic method, using a series of questionnaires for each panel member. The facilitator would also be active in guiding the discussion, controlling for natural leaders and opinion makers that could dominate the groups' decision. In most situations during the session, reasonable consensus was achieved, with few cases of deadlocks and disputes.

This weighting session comprised two rounds to assess the differences on perceived importance of pedestrians concerns according to journey purpose. On the first round, the focus was on utilitarian walking, where participants would place their mindset on a daily basis utilitarian walk, e.g. from home to work. On the second round participants should change their mindset to a recreational walk, e.g. a Sunday strolling with their family. Using the same key concerns as criteria for weighting different walking purposes - utilitarian and recreational - was a methodological option to enable a weight comparison.

4 Results

Process results are presented in Table 1 and Table 2, and later discussed. Table 1 shows the results from both rounds of the structuring phase. Stakeholders were sorted in 4 pedestrian user groups and asked to rank a set of 5 key concerns in each one of the 7Cs. The results for round 1 show the obtained rankings for each pedestrian group, as well as an aggregate score of each key concern related to the remaining set of 34 key concerns. The results for round 2, where stakeholders were free to rank concerns independently of the 7Cs, are also presented as an aggregate score.

<table>
<thead>
<tr>
<th>Table 1. Structuring phase results</th>
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<tbody>
<tr>
<td>Dimension</td>
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<table>
<thead>
<tr>
<th>C1: Connectivity</th>
<th>C11: Street density (alternative routes)</th>
<th>0.13</th>
<th>0.07</th>
<th>0.13</th>
<th>0.06</th>
<th>0.014</th>
<th>0.017</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C12: Continuity of walking path/sidewalk</td>
<td>0.27</td>
<td>0.37</td>
<td>0.25</td>
<td>0.33</td>
<td>0.043</td>
<td>0.084</td>
</tr>
<tr>
<td></td>
<td>C13: Path directness</td>
<td>0.27</td>
<td>0.17</td>
<td>0.04</td>
<td>0.44</td>
<td>0.031</td>
<td>0.036</td>
</tr>
<tr>
<td></td>
<td>C14: Existence of dedicated pedestrian infrastructure, accessible to all groups</td>
<td>0.10</td>
<td>0.33</td>
<td>0.50</td>
<td>0.17</td>
<td>0.039</td>
<td>0.059</td>
</tr>
<tr>
<td></td>
<td>C15: Network integration in the urban fabric</td>
<td>0.23</td>
<td>0.07</td>
<td>0.08</td>
<td>0.00</td>
<td>0.015</td>
<td>0.027</td>
</tr>
</tbody>
</table>

| C2: Convenience  | C21: Land use diversity                    | 0.27 | 0.20 | 0.13 | 0.28 | 0.031 | 0.044 |
|                  | C22: Sidewalk available width              | 0.23 | 0.07 | 0.25 | 0.22 | 0.026 | 0.013 |
|                  | C23: Obstacles (absence of)                | 0.20 | 0.23 | 0.21 | 0.28 | 0.032 | 0.034 |
|                  | C24: Density of daily uses                 | 0.23 | 0.33 | 0.17 | 0.11 | 0.032 | 0.025 |
|                  | C25: Facilities for accessing steep streets (escalators, elevators, ramps) | 0.07 | 0.17 | 0.25 | 0.11 | 0.021 | 0.036 |

| C3: Comfort       | C31: "Eyes on the street" - windows and facade transparency | 0.20 | 0.20 | 0.17 | 0.39 | 0.032 | 0.036 |
|                  | C32: Pavement surface quality               | 0.40 | 0.33 | 0.33 | 0.22 | 0.047 | 0.065 |
|                  | C33: Amenities (trees, benches, lighting, etc.) | 0.10 | 0.23 | 0.29 | 0.17 | 0.028 | 0.027 |
|                  | C34: Climate protection (sun, rain)         | 0.07 | 0.17 | 0.13 | 0.22 | 0.020 | 0.017 |
|                  | C35: Sensory quality of urban environment   | 0.23 | 0.07 | 0.08 | 0.00 | 0.015 | 0.002 |

| C4: Conviviality  | C41: Opportunities for meeting and sojourning (benches, tables, terraces) | 0.27 | 0.33 | 0.21 | 0.22 | 0.038 | 0.055 |
|                  | C42: Existence of "anchor sites" - squares, open-air markets, parks, etc. | 0.20 | 0.27 | 0.29 | 0.33 | 0.038 | 0.029 |
|                  | C43: Mixed uses and mixed working hours    | 0.33 | 0.13 | 0.21 | 0.22 | 0.032 | 0.013 |
|                  | C44: "Active edges" - absence of blank walls, empty lots, dull facades | 0.03 | 0.17 | 0.17 | 0.22 | 0.020 | 0.023 |
|                  | C45: Population density                    | 0.17 | 0.10 | 0.13 | 0.00 | 0.015 | 0.015 |

| C5: Conspicuousness | C51: Landmarks                          | 0.43 | 0.37 | 0.21 | 0.50 | 0.025 | 0.011 |
|                     | C52: Clear sightlines                    | 0.13 | 0.13 | 0.17 | 0.17 | 0.021 | 0.002 |
|                     | C53: Street names, signposting, way marking | 0.10 | 0.17 | 0.46 | 0.17 | 0.031 | 0.019 |
|                     | C54: Architectural complexity            | 0.13 | 0.10 | 0.17 | 0.11 | 0.018 | 0.008 |
|                     | C55: "Sense of place"                    | 0.20 | 0.23 | 0.00 | 0.06 | 0.020 | 0.006 |

| C6: Coexistence    | C61: Traffic safety (at pedestrian crossings) | 0.37 | 0.43 | 0.33 | 0.28 | 0.052 | 0.076 |
Results from both structuring and scoring phase point out important differences in the perceived importance of concerns (and related built environment factors that influence walking) by pedestrian type and by trip purpose.

It can be seen from Table 1 that distinct pedestrian groups have distinct concerns, and, although there are common concerns, there are no consensual concerns. In some cases, the most important concern for one pedestrian group is found to be completely neglected by other group. In other cases the highest ranked concern is not obvious due to very close or tied scores. From this results 4 distinct sets of concerns were drawn, one for each pedestrian group. The most agreed concerns were related to Comfort – quality of pavement surface and to the existence of landmarks, as well as traffic safety at pedestrian crossings. The least agreed concerns were related to Convenience.

Comparing round 1 and round 2 results, it can be seen that by changing the selection method (free range choice vs. constrained choice) the key concern ranking also changes, which allows analysing the relative perceived importance of each of the 7Cs. It is fairly accepted that factors related to accessibility play a major role, and hence connectivity concerns should naturally stand out. Previous and similar studies also underline the importance of traffic safety and personal security. The latter was addressed in this study as a “Comfort” concern, potentially expressed by the natural surveillance provided by the built environment ("eyes on the street") and had a relative modest global score. On the other hand Connectivity and Coexistence concerns accumulate 43% of the global score. It is also noticeable the discrete importance given to Conspicuousness concerns, either related to way finding elements or site legibility. If the results from round 2 were to be used for the weighting phase, there would be no contribution from the Conspicuousness or from the Commitment layers.

Table 2. Scoring phase results

<table>
<thead>
<tr>
<th>1000 Minds Weight results</th>
<th>Walking for transport</th>
<th>Walking for leisure, recreation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimension</td>
<td>Key-concerns</td>
<td>Adults</td>
</tr>
<tr>
<td>--------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.17</td>
</tr>
<tr>
<td>C1: Connectivity</td>
<td>C12: Continuity of walking path/sidewalk</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C13: Path directness</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>C14: Existence of dedicated pedestrian infrastructure, accessible to all groups</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.06</td>
</tr>
<tr>
<td>C2: Convenience</td>
<td>C21: Land use diversity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C22: Sidewalk available width</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>C24: Density of daily uses</td>
<td>---</td>
</tr>
<tr>
<td>C3: Comfort</td>
<td>C31: &quot;Eyes on the street&quot; - windows and facade transparency</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>C32: Pavement surface quality</td>
<td>0.17</td>
</tr>
<tr>
<td>C4: Conviviality</td>
<td>C41: Opportunities for meeting and sojourning (benches, tables, terraces)</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>C42: Existence of &quot;anchor sites&quot; - squares, open-air markets, parks, etc</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>C43: Mixed uses and mixed working hours</td>
<td>0.17</td>
</tr>
<tr>
<td>C5: Conspicuousness</td>
<td>C51: Landmarks</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td>C53: Street names, signposting, way marking</td>
<td>---</td>
</tr>
<tr>
<td>C6: Coexistence</td>
<td>C61: Traffic safety (at pedestrian crossings)</td>
<td>0.22</td>
</tr>
</tbody>
</table>
Table 2 shows the results from the scoring phase, in which stakeholders were sorted by pedestrian user group and questioned on their preference on hypothetical situations with the aid of decision-making software. A distinct set of key concerns was used for each user group, resulting from the previous selection stage.

Similarly to the previous stage, it can be seen that the perceived importance of pedestrian environmental key concerns varies by user group. It is also clear the distinction of perceived importance by trip purpose.

When focusing on utilitarian walking, coexistence concerns, related to traffic safety and location of pedestrian crossings, were considered to be the most important by all groups. Comfort concerns were also found to be very relevant to all groups, translated in the quality of pavement surface and on the natural surveillance of transparent facades, related to the perception of personal security.

When looking at leisure walking, the perceived importance of connectivity concerns dropped significantly, whilst the perceived importance of conviviality concerns rises consistently in all user groups. According to the adopted process of selecting and weighting pedestrian concerns to be included in a walkability assessment tool, there would be significant differences on the perceived importance of key concerns by user group and by trip purpose. This suggests that there is a need to formulate not one evaluation equation but different walkability evaluation equations. In this case, 17 different indicators would have to be developed to meet pedestrians’ concerns. Applying the estimated relative weights to these indicators would allow analysing the pedestrian environment through distinct user’s lenses and by walking purpose.

5 Discussion and conclusions

The research work hereby presented does not seek to providing another “right” set of built environment factors to be used in walkability analysis but to contribute in bridging an implementation gap of existing walkability assessment tools.

Our research shows consistent results with similar studies that point out the distinct quality needs per pedestrian user group; the influence of trip purpose on the perceived importance of environmental factors; and the influence of the urban context where the environment is to be assessed (Park et al., 2014; Lee and Talen, 2014; Guo and Loo, 2013; Weinberger and Sweet, 2012; Cambra, 2012; Manaugh and El-Geneidy, 2011; COST 358, 2010; Cao et al., 2006; Pikora et al., 2003).
Moreover, it is the first attempt to provide a comprehensive process of selecting and weighting pedestrian concerns, linking experts and stakeholders' points of view, suited to the local context, in this case, the Portuguese urban environment.

There are several limitations in the process and in the development of the walkability assessment framework emerging from this research.

Firstly, from the expert's interviews, the lack of agreement on the selection of key concerns for assessing the pedestrian environment was evident, being very challenging to incorporate all experts' perspectives, suggestions and corrections. Secondly, there was not a clear match between literature insights, expert's inputs and stakeholders' points of view, which can be related to less clear communication of the matters at stake, but can also be related to personal beliefs, experiences and perceptions. Thirdly, due to operational limitations of the weighting process only the highest ranked concern of each dimension was selected as weighting criterion. This issue was particularly noticed when the concerns' ranks were tied.

The composition of both the expert and stakeholder panel can also be considered a limitation on itself for the validation of the presented results, as a different composition or a larger participation could have produced different outcomes. As noted by Ewing and Handy (2009), "obviously, the validity of the results is no better than the quality of ratings by the expert panel."

Lastly, empirical evidence on which factors are the most relevant to walking behaviour is still lacking, and researchers from the various fields have not yet come to an agreement on what to assess or how to do it. However, given the importance of providing objective data to policy makers and practitioners in order to sustain and promote walking strategies, several methods have been used to overcome this issue, combining expert opinions and user consultation on needs, aspirations and perceptions (Batista e Silva et al., 2013; Ewing and Handy, 2009).

There is at the present a necessary and delicate balance between assembling a walkability framework based on robust evidence on the built environment factors that influence walking and that can be objectively measured, and assembling one that can be flexible in terms of user needs and perceptions and operational to a wider field of applications.

The presented work should facilitate ongoing research on assembling such walkability assessment framework. Albeit the current limitations to walkability measures, their potential applications and contribution to the future of cities, are reasons to believe that they will evolve and mature into robust planning tools.

To the question of "which factors are more important in influencing walking", the major answer still is "that we know too little" but from the multiplicity of urban attributes that may influence walking, accessibility and attractiveness of the pedestrian environment seem to play a major role. As walking has become an increasingly popular topic and research object, considered as the basis of the sustainable city, one key challenge is to provide policy makers with tools to assess the pedestrian environment appropriately in order to effectively prioritize projects and quantify the benefits of investments (Guo and Loo, 2013).

As referred previously, our research does not aim to provide another "right" set of built environment factors. Instead, it intends to propose an operational procedure to structure a flexible
walkability assessment tool that accounts for different pedestrian users (adults, elderly, impaired and children), for different trip purposes and that is adaptable to different urban contexts. This work goes further in presenting the perceived importance of pedestrian concerns translated into factor weights, which can be used to perform a broad set of analysis and that will be further elaborated in future developments.

Moreover, the assessment of quality, in terms of what environmental factors should be considered to be more important to people, has been regarded has of a highly subjective nature, as people’s needs and expectations differ per person and per situation, and furthermore, they change over time.

The presented process also contributes to bridge a gap between policy makers, scientific research and public participation on such a transversal subject as walking and promoting a walking friendly environment. In the words of Rob Methorst, quality for pedestrians concerns all stakeholders –public space users, providers and policy makers – and in this subject, “what is important is a political question, to be decided by all politicians” (Ramos and Alves, 2010).

References
BRIDGING THE IMPLEMENTATION GAP
OF ACCESSIBILITY INSTRUMENTS AND PLANNING SUPPORT SYSTEMS


Park S, Deakin E, Lee JS (2014) "Developing Perception-Based Walkability Index to Test Impact of Micro-Level Walkability on Sustainable Mode Choice Decision”, Transportation Research Board 93rd Annual Meeting.


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