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Development of a Measuring Tool for Walkability in the Street Scale - the case study of Hamburg

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Abstract. The humanistic approach is a key principle of any urban development with the aim of urban quality improvement. A healthy environment is fundamentally associated with walkable communities. According to a study in 2016 from the Centre for Diet and Activity Research (CEDAR) and the Medical Research Council Epidemiology Unit at the University of Cambridge, the health benefits of walking and cycling override the negative impacts of air pollution on health even in highly polluted cities. Additionally, planning walkable cities promote low carbon emission developments. Measuring walkability of the streets makes it possible for the planners and experts to address the quality of the built environment. This paper reports a practical assessment tool, developed in a master thesis, based on decisive walkability features by applying a weighting system to score those features in order to achieve a tangible outcome. For this reason, an examined weighting system from a previous study led by the Institute of Urban Planning and the University of Duisburg-Essen is optimized. Afterward, the proposed tool is applied for measuring the walkability in a selection of different streets in Hamburg, in order to answer the questions of how these Hamburg's streets differ in their degree of walkability and how their walkability can be improved.

1. Introduction

As John Gehl once said, cities should be given back to their people [1]. This means considering the human scale and that human needs should become a priority in every urban development. Walking is the primary human transit mode and embeds the interaction between pedestrians and their surrounding built environment. Walkability is not necessarily related to the amount of walking or how vibrant a street is but is a precondition for a positive correlation between walking and the daily pursuits [2]. The activity of walking can be considered as necessary (for shopping and commuting), optional (for sight-seeing or pleasure) and social (combined with sitting, reading, or talking). A livable urban environment is a place that also provides facilities related to activities such as sitting, talking or enjoying public art [3]. The literature of humanizing urban design began in the 60s in the US when large-scaled and car-oriented cities had taken away the urban life from their inhabitants. Livable streets and neighborhoods with safety, cleanness, and security were mentioned to be one of the most important characteristics of a livable urban environment [4]. After decades, livable streets and walkability are still the most important solutions encountering new problems like air pollution, concerns about fossil fuels and public health issues. Obesity has tripled in WHO European Region since the 1980s [5]. Improving walkability can improve both the built environment and public health. This would happen through improving the "sidewalk room", considered as the essential element of urban space. The analysis of the degree of walkability at the street scale is focused on the spatial quality of a sidewalk, defined through its four edges [6] and how it can affect the walkability features. A study on measuring and recording walkability in mixed-use streets of the city of Essen has been carried out by the Institute of Urban Planning and the University of Duisburg-Essen in 2017 ("Essen report", [7]). Its methodology uses indexes, referring to different walkability features, and a weighting system to calculate the final score (see table 2). It is based on previous studies in American cities (see [7]) and was adapted to European cities, which are typically part of an old urban system from middle ages where the system of pedestrian areas, cycling paths and large public transportation has remained over the time despite sprawling [8]. The proposed tool in this paper is developed by further optimizing the methodology of the Essen´s report, in order to achieve a more comprehensive and applicable measuring tool for walkability in the street scale.

2. Walkability features

In previous studies, various physical features and perceptual qualities of walkability have been identified. They differ from being more objective to more subjective (reflected by individual reactions to a place) [9]. Existing methodologies often solely refer to (directly measurable) objective criteria or cover indexes related to perceptual qualities, without presenting and ordering them in a deeper relation. Consequently, there is a risk that the methodology does not describe all aspects of the phenomenon of walkability enough and that correlations between the different used features remain invisible.

For this reason, here it is proposed to relate first to the human needs, like in Max-Neef's human needs chart [10], and how fare they are touched by walking through a city. That allows defining a group of central features describing the context and to bring them into an order where the prior one is a precondition for the following one (see table 1). The features of connectivity and security are the essentials for walkability, operating in parallel. No connectivity means an access is missing. However, one would not choose to use a path if no physical security is guaranteed, even when the access provided. The scale of analysis for connectivity is the neighborhood scale, in which the connection between different nodes can be studied. Regarding this scale, connectivity is not included in this paper. Apart from security, pedestrians also need to feel that themselves and their belongings are safe while walking on the sidewalks, which are additionally stable, well maintained and secure [11]. Therefore, safety becomes another decisive feature. According to Jan Gehl's quality criteria for good design of public spaces [12], other features that refer to protection and comfort come next. Thereupon, the first three essential prerequisites for walkability in street scale are the feeling of security, safety, and comfort. Other available features refer to the urban quality, which most essential ones in the street scale are identity, attractiveness, and invitingness (the state of being inviting to gather people together).

Table 1. Table of features and index classification.

	Feature	Index (extracted from the Essen's report)	
Driven from the human need chart [9] and quality design criteria	Feeling of security	Street hierarchy type / Street traffic type / Parked cars / Buffer	Physical indexes
	Feeling of safety	Sidewalk width and street width ratio / Tree canopy	
	Feeling of comfort	Sidewalk width / Obstacle / Hindrance / Barrier freeness / Accessibility /Urban furniture / Active tram or bus line on the street / Public transportation stations / Other greenery	
	Identity	Landmarks	
	Invitingness	Number of gastronomy units / Number of gastronomy units with outdoor setting / Number of retail stores/ Supermarkets along the sidewalk / Presence of public places / Presence of vacancy	
	Attractiveness	Façade maintenance condition / Street cleanness condition / Street façades complexity / Presence of artwork	Perceptional indexes

Each walkability feature can be identified through special groups of indexes. The value of a feature can be measured through the value of its indexes. The indexes in the table are extracted from the Essen´s report, which is briefly explained in the next chapter.

3. Tool development

Table 1 is the basis of the proposed tool in this study. An appropriate scoring system is required in order to attain a tangible degree of walkability in the street scale. The weighting system from the Essen's report acts as a reference to this tool. In the Essen's report, walkability indexes are investigated in a different classification which is regardless of the walkability features (see table 2). Therefore, in a street analysis, it would be impossible to figure out which features need to be improved or which perform satisfactorily. What makes this study distinguished is a weighting system used to score each category of the mentioned classification. According to this study, each index has a different weight in the total value. The weighting system was achieved by an interdisciplinary expert panel. The experts have weighted independently and then the average of weights was determined (see tables 2 and 3).

Table 2. A segment of physical features index from the Essen's report (see [7]).

Index group	Index	Category	Score	Category weight
1. Sidewalk (criteria weight = 30%)	Sidewalk width	No sidewalk < 1.5 m 1.5m -2.5m 2.5m -5m >5m	1 2 3 4 5	24.40 %
	Buffer	None / only curb Parked cars Bicycle path Flower boxes Green part	3 3 4 4 5	20 %
	Obstacle / hindrance	Very disturbing Disturbing None / not disturbing	1 2 5	17.50 %
	Barrier freeness / Accessibility	Yes Partly No	5 3 1	13.10 %
	Sidewalk width and street width ratio	>70% 61-70% 60% 50-59% <50%	5 4 3 2 1	25 %
2. Street (criteria weight = 35%)	Street type	Local street Collector street Sub arterial road Arterial road Other	5 4 3 2 1	21.40 %
	One-way street	No, pedestrian zone No Yes	5 3 4	7.70 %

Table 3. A segment of urban quality index from the Essen's report (see [7]).

Index	Category	Score	Weight 0-9
Landmarks	1 0	5 3	6.5
Street space condition	Bad condition High pollution Very high pollution Low pollution	1 2 3 4	5.9

The tables in the Essen's report uses step weight factors for each calculation in a set of formulas. However, the tables above have different total weight factors. For table 2 it is 100; while for table 3 with weighting from 0-9, the total is 64.7. By simply multiplying each weight factor to the related score factor and then dividing by the total weight, a single weight factor would be assigned to every single index. This single weight factor is, in fact, the final score calculated for each index. This will make the new arrangement of indexes (see table 1, plus table 1 in the appendix) possible. As an example from the second index group in table 2: the index "Street type" has a weight factor of 21.40%, and belongs to the index group "Street" which has a weight factor of 35%. If a category in "Street type" index has the score factor of 5, then the final score for this category will be:

$$\text{Category 's final score} = (5 \times 21.4)/100 \times 35/100 = 0.3745$$

By using this method, a new weighting system can be achieved in which every single category of the index groups has independent weight. A similar method is used to reach the single weight for the categories from urban quality index table in the Essen's report (see table 3). The two finalized tables: Street Physical Index (SPI) plus the Street Quality Index (SQI) (see tables in the appendix), have been provided in a spreadsheet software with the new single weight factors and new index arrangement, in a way that they would be easily applied by clicking on the desired category. After clicking, the final score factor will appear as well as the sum of these score factors will be automatically calculated. To check the validity of the new tables, the sum of all scores from the whole categories should be 5 when selecting the maximum rate in every case. The corresponding maximum score factor for each index is directly shown in the tables. This maximum score factor adapts to other corresponding score factors. For example, in the street hierarchy type index, the maximum score factor is 5 and the final score for an arterial road is 2. This can be calculated with this formula: 2/5 x 0.3745 = 0.1498.

Finally, the relationship between the physical characteristics and the urban qualities, mentioned as the Integrated Walkability Index (IWI) in the Essen's report and as walkability degree in this paper, is calculated with the weight factors shown in the formula below. By implying the final scores into the new tables, the walkability degree will be between 2.1-5:

$$\text{Walkability Degree} = (\text{SPI} \times 52.85) + (\text{SQI} \times 47.15) / 100$$

Furthermore, the description of a few indexes from the Essen's report needed to be adapted in order to improve comprehensibility. For instance, in the index of sidewalk width and street width ratio (see table 2) there is no possibility to choose between 60-61% and 59-60%, therefore the category is changed accordingly to cover all possible numbers. Another example is the index street facades complexity that has the category of heterogeneous with the highest score and homogeneous with the least score. Whilst in the topic of street scale, it is important if a facade is pleasant to watch or not. A façade can be homogeneous and at the same time pleasant to watch. Therefore, the new category is changed to street facades complexity: "a pleasure to watch" or "boring". Additionally, in this tool, the corresponding street length set for every index is 250 meters except for the indexes referring to the number of gastronomy units, which require a different reference length. World's great streets such as Regent Street in London, Les Champs-Elysées and Boulevard St. Michel in Paris have an average of one new public function at least in every 15 meters, which means 6-8 units in every 100 meters [13]. Therefore, more than 5 gastronomy units in 100 meters receive the highest score (while in the Essen's report, more than one unit is considered adequate to receive the maximum score). This tool has been applied to measure walkability in some streets in the city of Hamburg by collecting data through observation. There might be uncertainties when applying this tool. For instance, both sidewalks of a street may not have the same condition. For the scoring purposes, both sidewalks should be checked, and the highest score should be selected. In the following chapters, some of the application results are briefly described.

4. Walkability in Hamburg streets

Hamburg is a typical European city with the corresponding quite dense street grid. Some streets are always preferred by walking people and some others are not. By applying this tool, it will be possible to understand if a street is as walkable as it looks and what reinforces or deteriorates its walkability. Six streets were selected for this study. Some of them are well known as being walkable and some others are usually desolated. One arterial road was selected in order to obtain low scores and to better comprehend the meaning of the walkability degree, scored between 2.1 - 5. At first sight, two of the six investigated streets seemed to have completely different potential of walkability, but after the assessment was done, their walkability degrees resulted quite alike. These streets are briefly described and compared as follows.

4.1. Muehlenkamp

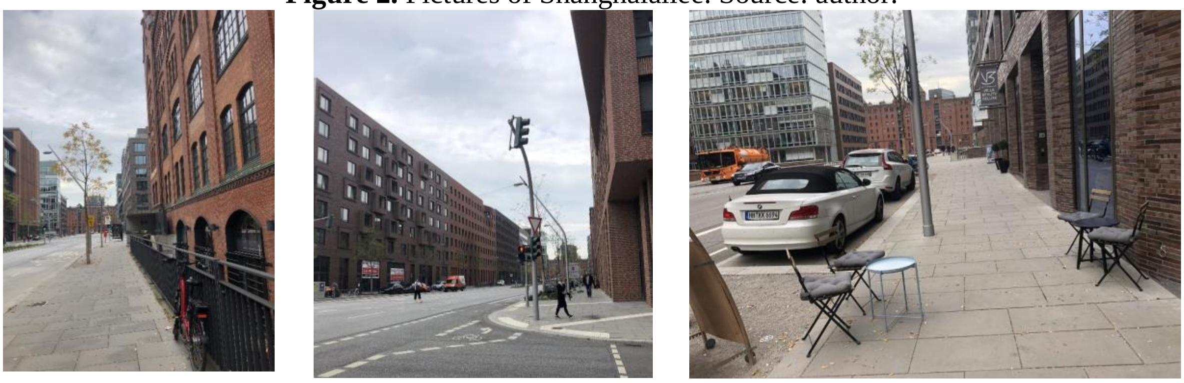
This street is the main street of a sub-center and perceived as one of the vibrant streets of Hamburg with many gastronomy units, supporting commercial and service units. Muehlenkamp is a two-way collector street with partly more than two lanes. The buffer between the street and the sidewalk is a bicycle path and there is a row of trees in the sidewalk. The sidewalk width varies from 2.5m - 5 m and the street width (building edge to building edge) is 20 m. The sidewalk width ratio (one sidewalk width divided by the total width of the street) is less than 50%. The width of the footway is not fixed through the street and in narrow parts there are some disturbing obstacles like product shelves in front of some shopping unit, while not every part of the sidewalk can be freely accessed. The sidewalks and the facades, with buildings of around 1900, can be scored as with “low dirtiness”.

Figure 1. Pictures of Muehlenkamp. Source: author.

4.2. Shanghaiallee

Shanghaiallee is part of the newly built HafenCity neighborhood with new and clean buildings. Less vibrancy and usually empty sidewalks make it distinguishably different from Muehlenkamp. However, the structural characteristics of this street which define the feeling of security are the same as Muehlenkamp. Also, Shanghaiallee has sidewalks free of barriers but with less greenery.

Figure 2. Pictures of Shanghaiallee. Source: author.



4.3. *Feature score comparison*

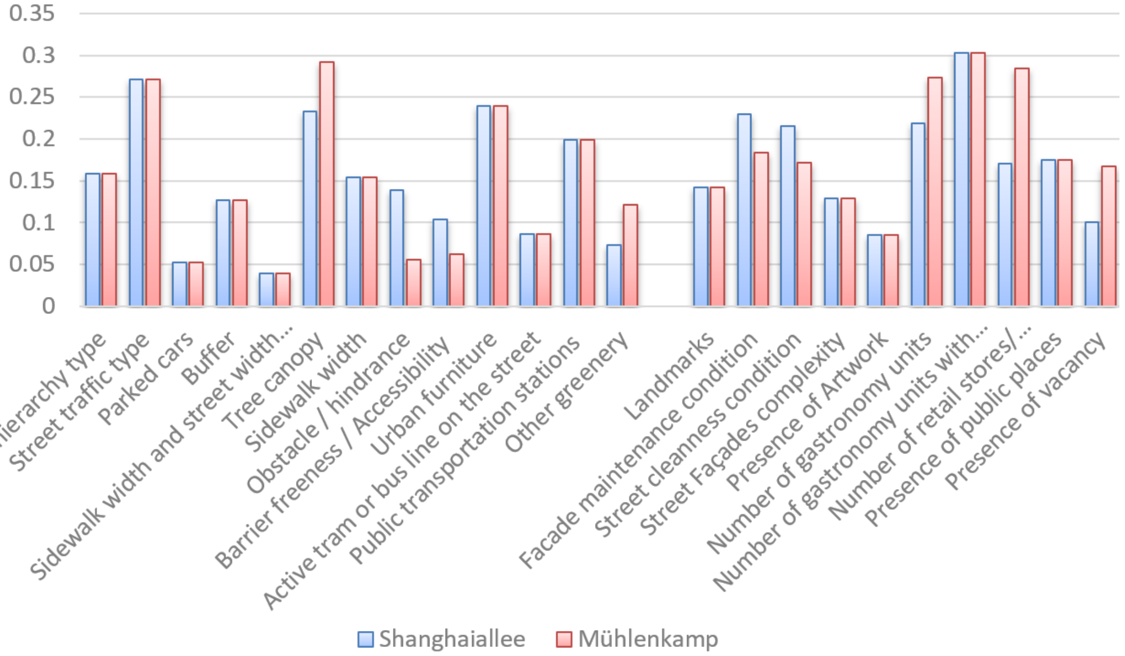
After visiting the two mentioned streets, it can be perceived that Muehlenkamp is much more vibrant than Shanghaiallee, since its sidewalks are full of people and sometimes even crowded.

Table 4. Feature score comparison from two investigated streets

Street name	Feeling of security	Feeling of safety	Feeling of comfort	Identity	Attractiveness	Invitingness	Walkability degree
Muehlenkamp	1.15	0.63	1.74	0.3	1.20	2.55	3.77
Shanghaiallee	1.15	0.52	1.90	0.3	1.40	2.05	3.64

However, by calculating the walkability degree, there is a minor difference between these two streets (see table 4). This shows that Shanghaiallee is nearly as walkable as Muehlenkamp and has all preconditions to become vibrant. Shanghaiallee has well-maintained façades, spotless sidewalks, full accessibility, and no hindrance, which prevents a drop in the walkability degree. Still, the weak invitingness leads to empty sidewalks.

Figure 3. Index comparison chart, Muehlenkamp & Shanghaiallee.

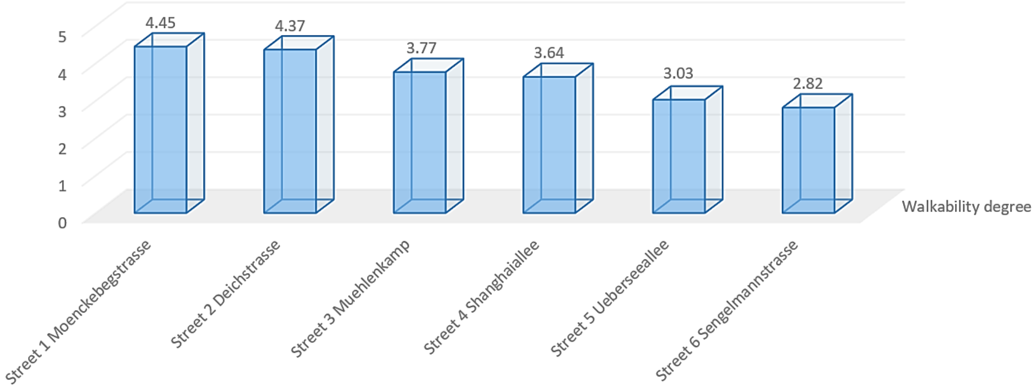


Increasing the gastronomy units and other units with supporting public functions can effectually improve walkability in this street. Street analysis by evaluating each index as well as index comparison among streets are possible through this tool. Figure 3 illustrates the index comparisons of the two mentioned streets.

5. Tool results analysis

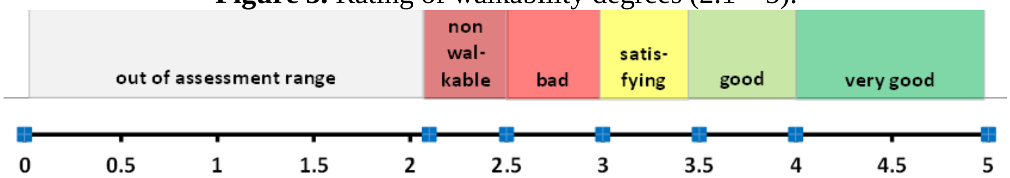
Various streets from absolute car-oriented to car-free ones were selected to be assessed by this tool. This permitted to reach a tangible range of walkability's degrees for the final assessment (see figure 5). The proposed tool gives the possibility to analyze streets in several terms: regarding their features, the indexes or the walkability degree. For instance, among six investigated streets, the lowest degree (2.82) applies to an arterial road with car-oriented design, while the two highest degrees belong to relatively car-free streets, with and without an active bus line (see figure 4).

Figure 4. Walkability degree in analyzed streets.



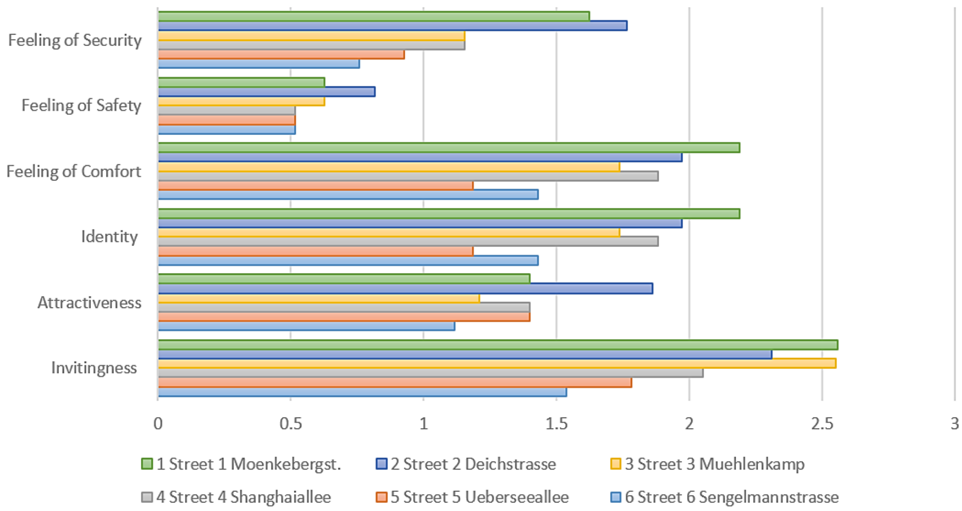
According to the results, the degrees can be interpreted as follows:

Figure 5. Rating of walkability degrees (2.1 – 5).



The lowest possible degree that can be achieved by this tool is 2.1 and the highest is 5. The walkability situation of the investigated streets of Hamburg, therefore, can also be interpreted besides the numbers. In other words, the streets no.1 and 2 have very good walkability. Streets no.3 and 4 can be classified as good while no.5 is satisfying, and no.6 is bad. Another way to analyze the driven data is to compare the streets according to their features (see figure 6). In this way, the features that need to be improved would be distinguished. For instance, street no. 5 is a sub-arterial where the walkability needs to be enhanced. As shown in figure 6, the feeling of safety and security is low in this case. Any intervention that strengthens these features, such as adding green areas as a buffer or create a tree canopy, can improve the total score. The street no.4 has an equal level of safety as the street no.5 but higher scores in comfort and invitingness, which contributes to achieving a good grade of walkability.

Figure 6. Feature score comparison in analyzed streets



6. Conclusion

Walkability is a vast topic, containing numerous variables and indicators. The proposed tool includes all essential indicators for walkability. It offers various possibilities to analyze a street and delivers tangible results in accordance with expectations. An important data driven from this tool is the walkability degree between 2.1-5. Assessing perceptibly walkable as well as non-walkable streets allowed to define a rated scale for walkability degrees.

This tool can also be applied outside Europe with small adaptations. In the first table of the appendix (SPI) the indexes refer to physical and structural preconditions of a walkable street, thus they are always valid regardless to the culture or climate except for one index referring to public transportation: active tram or bus line can be replaced by any other local public transit mode. In the second table of the appendix (SQI), indexes regarding gastronomy units might need to be tailored. For example, in a country like Malaysia, street food stands characterize the streets and attract people, the reason why the number of food stands should be considered in the index of gastronomy units.

In fact, if a street is certainly walkable or not depends on how a pedestrian perceives it. One can assess the same street differently depending on the person's mood or background. People's age, gender, nationality, being a tourist or not etc. can affect the perception as well. This is nearly unmeasurable and makes the limitation of any measuring tool for walkability. For this reason, it is always recommended to interview different people and inhabitants in diverse timeframes to achieve a higher level of comprehension about walkability.

For a deeper investigation, this tool can be applied separately to each sidewalk of a street. Index scores always refer to the best existing condition even if it is not the same along the sidewalk. Therefore, a checklist recognizing potentials improvement can also be attached to the tool for the cases that sidewalk segments differ in terms of scoring.

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References

[1] Gehl J 2010 *Cities for people* (Island press)
[2] Ng S, Lau W, Brown F, Tam E, Lao M and Booth V 2012 *Walkable City, Living Streets* www.civic-exchange.org
[3] Gehl J 2004 *Towards a fine city for people* (Transport for London & Central London Partnership)
[4] Jacobs A & Appleyard D 1987 *Toward an Urban Design Manifesto* APA Journal www.semanticscholar.org
[5] World Health Organization 2018 *Obesity*, http://www.euro.who.int/en/health-topics/noncommunicable-diseases/obesity
[6] NYC (City of New York) 2013 *Active design. Shaping the sidewalk experience* (E-book) retrieved from https://www1.nyc.gov/assets/planning/download/pdf/plans-studies/active-design-sidewalk/active_design.pdf
[7] Institut für Stadtplanung und Städtebau, Universität Duisburg-Essen 2017 *Messung Und Erfassung Der* Fussgängerfreundlichkeit *Von Stadträumen* (PDF) retrieved from https://www.uni-due.de/imperia/md/content/staedtebau
[8] Le Gales P 2007 *Cities are back in town: the US/Europe comparison* (PDF) Sciences Po http://blogs.sciences-po.fr/recherche-villes/files/2010/01/cahierville0606.pdf
[9] Ewing R & Clemente O 2013 *Measuring urban design, metrics for livable places* (Island Press)
[10] Max-Neef M 1991 *Human Scale Development* (New York: The Apex Press) p 32
[11] Department of Transport 2011 *Walkability Audit Tool* (Western Australia: Department of Transport) p 2
[12] https://gehlinstitute.org/wp-content/uploads/2017/08/quality-criteria-final.pdf
[13] Karssenberg H Laven J Glaser M & Hoff M 2015 *The city at eye level, lessons for street plinths-Hans* Karssenberg (PDF) Eburon

Appendix

Table 1. First table of the finalized tool; Street Physical Index (SPI)

Feature	Index	Category			Score	Final score
Feeling of security	Street hierarchy type	Local street			☑ 5	0.3745
		Collector Street			☐ 4	
		Sub Arterial Road			☐ 3	
		Arterial Road			☐ 2	
		Highway			☐ 1	
	Street traffic type	Pedestrian (only bikes, Trams,	Yes		☑ 20	1.04475
			No			
				One-way street		
				Yes	☐ 4	
				No	☐ 3	
				Number of lanes		
				1	☐ 4	
				2	☐ 3	
				> 2	☐ 1	
				Speed limit		
				< 30km/h	☐ 4	
				30-50 km/h	☐ 3	
				> 50km/h	☐ 1	
				Pedestrian crossing type		
				Crosswalk	☐ 4	
				crosswalk	☐ 3	
				Partly crossable	☐ 2	
				No crosswalk	☐ 1	
	Parked cars	None			☑ 5	0.16625
		Beside/ on the street			☐ 3	
		On the sidewalk			☐ 1	
	Buffer	Green part			☑ 5	0.3
		Bicycle path			☐ 4	
		Post/flower boxes			☐ 4	
		Parked cars			☐ 3	
		None / only curb			☐ 3	
Feeling of safety	street width ratio	> 70%			☑ 5	0.375
		63-70%			☐ 4	
		57-63%			☐ 3	
		50-57%			☐ 2	
		<50%			☐ 1	
	Tree canopy	Tree row(s)			☑ 5	0.5515625
		Single trees			☐ 4	
		None			☐ 3	
Feeling of Comfort	Sidewalk width	> 5m			☑ 5	0.366
		2.5m -5 m			☐ 4	
		1.5m - 2.5m			☐ 3	
		< 1.5 m			☐ 2	
		No sidewalk			☐ 1	
	Obstacle / hindrance	None / not disturbing			☑ 5	0.2625
		Disturbing			☐ 2	
		Very disturbing			☐ 1	
	Barrier freeness	Yes			☑ 5	0.1965
		Partly			☐ 3	
		No			☐ 1	
	Urban furniture	Lighting + bench		Yes	☑ 5	0.3506875
		only lighting or no furniture		No	☐ 3	
		Bicycle stand		Yes	☑ 5	0.2421875
				No	☐ 3	
	Active tram or bus line	Yes			☑ 5	0.1645
		No			☐ 3	
	stations	Yes			☑ 5	0.375875
		No			☐ 3	
	Other greenery	Yes			☑ 5	0.2296875
		No			☐ 3	
Sum						5 / 5

Table 2. Second table of the finalized tool; Street Quality Index (SQI)

Feature	Index	Category	Score		Final score
Identity	Landmarks	at least one	5	☑	0.50231839
		none	3	☐	
Attractiveness	Facade maintenance condition	Good maintenance	5	☑	0.48686244
		Low dirtiness	4	☐	
		Medium dirtiness	3	☐	
		High dirtiness	2	☐	
		Bad maintenance	1	☐	
	Street cleanness condition	Good condition	5	☑	0.45595054
		Low dirtiness	4	☐	
		Medium dirtiness	3	☐	
		High dirtiness	2	☐	
		Bad condition	1	☐	
	Street Façades complexity	Pleasure to watch	5	☑	0.45595054
		Not Boring	3	☐	
		Boring	1	☐	
	Presence of Artwork	>1	5	☑	0.30139104
		1	4	☐	
		0	3	☐	
Invitingness	Number of gastronomy units	>5	5	☑	0.57959815
		1 to 5	4	☐	
		0	3	☐	
	Number of gastronomy units with outdoor setting	>1	5	☑	0.64142195
		1	4	☐	
		0	3	☐	
	Number of retail stores/ supermarkets along the sidewalk	>1	5	☑	0.60278207
		1	4	☐	
		0	3	☐	
	Presence of public places	Yes	5	☑	0.61823802
		No	3	☐	
	Presence of vacancy	0	5	☑	0.35548686
		1	3	☐	
			1	☐	
		>1			
Sum					5 / 5