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City Afoot – What the State-of-the-Art Walkable City Looks Like

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1 ABSTRACT

Walkability has been the subject of research for quite some time now. There are solid findings from a wide range of disciplines, and yet in reality the realization of pedestrian-friendly urban areas is rare. Why is that? Urban planning is a highly political undertaking; only a few politicians dare to incur the displeasure of the car lobby, the conservative economy and the - in their opinion - still car-driving and car-owning majority of voters. Rarely do decision-makers, like Anne Hidalgo or Leonore Gewessler at present, act seemingly free of fear of the next election. Regardless of this fact, the question arises: What would the state-of-the-art walkable city look like?

In addressing this question, this article not only provides a comprehensive research on walkability across the disciplines, but above all attempts to examine the findings to see whether they are suitable for implementation at all. For this reason, the second part of the text deals with the attempt to translate theoretical knowledge into the real-physical world within the chosen perimeter of the Vienna Westbahnhof site. The research by design method was chosen in order to transfer the partial knowledge about walking as a basic function of traffic science or as a leisure-immanent behavior, or about the parameters of quality of stay in public space into an inclusive planning basis. The aim was to detach planning from conventions and instead force a development of the built environment based exclusively on current walkability research.

Keywords: Public Space, Urban Development, Ground Floor, Mobility, Walkability

Fig 1: Part of the walkable city design at the Westbahnhofareal in Vienna © Tobisch

2 INTRODUCTION

“Stop counting and comparing! We have all the necessary facts at the table and we already know what needs to be done. Let's finally do it now.” With these words, Ute Schneider, the new professor of urban planning, began her first studio supervision at TU Wien in spring 2021. In this sense, this paper follows this call and tries to translate a well-founded factual situation into design: how must walkability be designed?

2.1 Relevance of Walkability as a Topic in Urban Design

Cities around the world advertise the walkability of their town centers as a special feature in the quality of urban life. However, it is important to notice that the roots of pedestrian friendly structures are to be found in pre-automobile times, when pedestrians represented the primary user group of public space. With the rise of individual motorized transport urban development started failing to meet essential life quality standards. But since the matter of the finite nature of our resources has become a critical concern in recent years, the walkable city has once again developed into a major focus in urban planning–primarily due to its resource efficient and sustainable land-use and its low-emission transportation. In order to meet the needs of

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pedestrians, a number of concepts have been implemented, based primarily on the restoration of walkable historic structures.

But what would a new state-of-the-art walkable city look like today?

Walkability is a heavily discussed topic and covered in various research fields. A plethora of studies across the fields have found a relevant link between mobility behavior and the built environment. Mode choices and therefore also walking seem to be closely associated with it. While there are some interdisciplinary approaches, the bulk of the studies are within the borders of one field of research.

As urban structure researchers/architects/urban planners we seek to shine light on what a "most walkable city" would look like nowadays, by aligning interdisciplinary results from scientific walkability studies with the real built environment.

2.2 Research Questions and Methodology

2.2.1 Questions

Considering the abundance of established and new research material and the resulting theoretical knowledge on the topic; but the – comparatively – rare attempts of practical integration of the state-of-the-art walkable city, the paper is addressing two main questions.

First of all, the fundamental question arises as to whether currently valid research results in relation to walkability can be applied at all in a practical design process and thus implemented in a real reference field. Secondly, the question of the implementation problems that arise in this context are to be clarified.

In order to be able to address these questions, i.e. to assess which implications for the design of real urban structures can be derived from scientifically recognized valid findings, this paper provides a comprehensive, cross-disciplinary overview of findings from walkability research.

2.2.2 Methodology

Scientific Literature Study

An extensive literature study on walkability was conducted in various research fields. Walkability research is pursued in fields like urban planning, transportation research, spatial planning, public health, economics, psychology, sociology, geography, ecology, architecture and more. The amount of available material varies widely, with urban planning, transportation science and public health easily being the most productive disciplines. These three disciplines use different approaches: while traffic planning focuses on the length and availability of routes, public health emphases on the amount of time spent walking and the constitution of environment that encourages physical movement, not unlike urban planning which is also dealing with the constitution of public space and its influence on the walking and staying behavior of users. The scale of the analysis is similar in the first two, being on an urban or district level, while urban planning seems to go much more into detail down to street or building level.

The findings are then categorized into the so-called D-variables, which reflect the state-of-the-art in walkability research–and originate in the field of transport research– there they are described as the primary influences on walking: Diversity, Design, Destination Accessibility, Distance to transit. (Cervero and Kockelman 1997, 199; Ewing and Cervero 2001, 114) The study includes two additional variables: Demand management and Demographics. Both are treated distinctively in research literature because, although they are not part of the physical, built environment, they still have an undeniably significant influence on walkability. (Ewing and Cervero 2010, 267) Substantial correlations and cross-causal relationships between the individual influences are analyzed in order to better assess the relationships between the D-variables. Thus, walking is being studied as a basic function in transport science, and equally as a leisure-immanent behavior, and in connection with this, of course, the quality of stay of public space is being analyzed.

- Research by Design

Research by design is used to investigate spatial solutions for a research area in an iterative design process to produce new knowledge or practices considering the area or the objective in general. (Roggema 2017) The results from the theoretical treatment of the topic are thus translated into parameters that allow the development of a built environment that is detached from conventions and instead based exclusively on current walkability research. The parameters developed in this way are then applied to a research area in

Vienna. The multitude of different design benchmarks that influence walkability, from regional coherence and urban structure to the arrangement of seating and surface design, are all taken into account from the beginning of the planning process. The result of that process is then reflected upon concerning the utility of the previously developed techniques in achieving a pedestrian friendly urban structure as well as the overall walkability of the design. Furthermore, the processes and tools that are available in urban planning at the moment are examined concerning their ability to ensure the development of walkable structures.

2.3 Objective

The objective of this study is to investigate what the state-of-the-art walkable city looks like by conducting an extensive literature research and developing a design process based on the priorly obtained knowledge. The multidisciplinary, research-based approach to walkable city design is expected to reveal weaknesses and underrepresented issues in both theory and practice. The aim is to challenge and rethink common practices and existing frameworks in urban planning to build the foundation towards high walkability in the city of the future.

3 WALKABILITY RESEARCH

Research on walkability was initially conducted in transportation research and was therefore mainly considering influences on walking for transportation, while the leisure aspect of walking was originally not included in the definition. (Saelens and Handy 2008) Only when other fields of research engaged in the topic walking for leisure and – since they are inextricably linked – the quality of stay of public spaces were added. The term walkability is no longer only limited to pedestrians, but is often used to describe an environment that is suitable for other non-motorized transport like cycling and various leisure activities as well. (Kerr 2014, 131)

4 D-VARIABLES

As described earlier, the D-variables are outlined in the following and checked for their applicability.

4.1 Density

The most widely used parameters population density, employment density and building density are good indicators for the amount of urban activity in the city. They are easily assessed and therefore most widely used, but they cannot offer definite statements especially not in single use environments.[1] Variations of the factor network density – either considered for the general network (streets) or for the pedestrian network (sidewalks, crossings and passageways) – stated in network meters per square meter of area - are also often used.[2] The term attractor density was introduced in an effort to clearly describe the connection between the density of certain uses in the ground floor of buildings and the walkability of the adjacent street environment.[3] While parameters like building density and network density can directly be applied to a planning area, this is not possible for those relating to the amount of functions or people that populate the city. These need to be implemented in combination with other D-variables.

4.2 Diversity

From walkability's perspective, the key-uses in the city are living, working, supply, leisure and education. The connection between them is ensured by the sixth use, which is traffic. Spatial segregation of the uses (e.g. because of functional zoning that intends for large, single-use areas) increases the need for traffic and the distances covered, which results in a high degree of macro-mobility. Diversity of uses however ensures short distances between different functions, which makes walking, cycling and public transport feasible for

[1] That is why they could be considered as poxy variables for walkability. (Forsyth et al. 2007, 682)

[2] This does not seem to be taken into consideration in most newly planned areas, block dimensions are usually large to be able to accommodate big individual developments, the resulting street networks can therefore not be considered walkable.

[3] Functions in the ground floor of buildings are highly influential for the amount and type of activity in the public space in front of them (see section 4.3.2). While living and certain workplaces are only intended for a limited user group, other functions are able to attract additional people, whether that might be as pupils, customers or visitors. Those functions are responsible for a large part of activity in the public realm and therefore a direct indicator of the walkability of that environment. (Tobisch 2021, 37)

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most everyday travel; thus, it generates a public space that promotes urbanity, i.e. a lively city life – which in turn, experience has shown, further increases walkability.[4] In practice, both the urban structure and the design of the buildings themselves need to be suitable for various different functions to enable a sustainable development of mixed-use environments.

Fig 2: Single-Use business district "Viertel Zwei"; Mixed-Use neighbourhood along the Märzstraße in Vienna © Tobisch

Uses outside of buildings, whether they might be in private or public spaces are usually not included in walkability research. Considering that these are most directly perceived when walking, their importance is evident and more attention needs to be placed both on the research and planning of these functions.

4.3 Design

Considering the multi-faceted effects of design aspects on walkability, the following sub-categories are introduced:

4.3.1 Functional Design

Functional design includes all design aspects that have the potential to shorten routes measurably. Because of the limited reach of pedestrians[5], permeability is one of the major restrictions of walkability, it is described by the factors intersection density and street connectivity. Pedestrian reach must be determined along the street network and not by linear distance, therefore the geometrical reach varies widely depending on network characteristics.

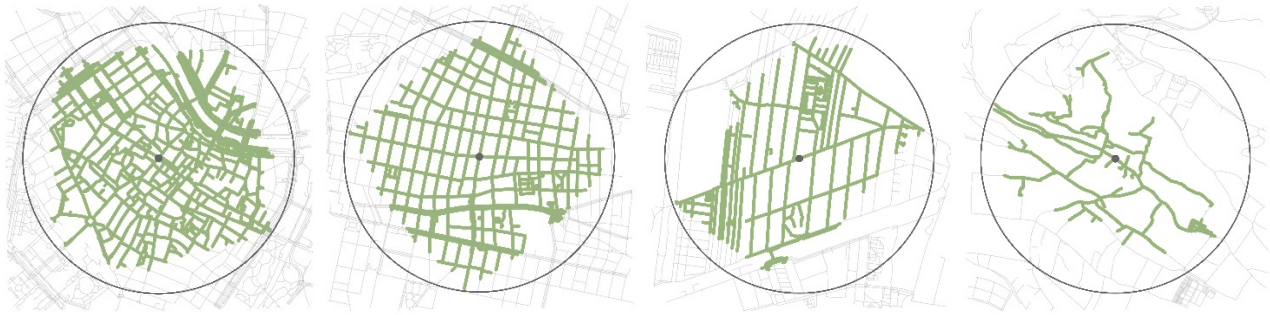

Fig 3: Permeability of different urban structures in Vienna, illustrated by the comparison of a 800 meters radius and the actual network covered with a travel distance of 800 meters in each structure respectively © Tobisch

An important statement is that intersections and street networks can only be equated with the walkable network in a pedestrian-only or shared space environment. In conventional street layouts where the different traffic strands are spatially separated, the pedestrian network does not consist of streets, but rather of sidewalks, intersections and passageways. Pedestrian sensitivity to detours at intersections and vertical routes such as under- and overpasses is high and further limits their reach, hence pedestrian connectivity must be carefully considered. The arrangement of buildings within the block and with that its permeability is highly

[4] While the number of individual activities seems to be the deciding factor for a space to be considered "active" the spread of those activities around the clock (Jacobs 1961, 154; Speck 2018, 14) and the length of the activities themselves (Gehl 2012, 72) are the key influences on the perception of the space.

[5] Various studies show that the willingness to walk decreases rapidly after only a few hundred meters. (Gehl 2012, 139; Walther 1973, 58-64) Precise statements about the reach of pedestrians are often made, but since they are dependent on a variety of factors (like walking environment, cultural and individual conditioning and availability of other modes of transport) and vary widely, they cannot be considered generally valid.

relevant for the length of the path that has to be covered to reach a destination, but also for the legibility of the public space and the perception of the functions on the ground floor.

4.3.2 Qualitative Design

Beside the distance factor, the environmental aspect is the main reason for encouraging walking: the path has to be attractive![6] What can be considered an attractive environment is determined by two factors, firstly the amount of space provided to pedestrians, which is in conventional street layouts indicated by the width of sidewalks.[7] The second factor results primarily from the circumstance of the comparably low speed of pedestrians and the resulting thorough sensory perception of the surroundings when walking.[8] Therefore, the public space needs to meet certain qualities and a and it needs to be interesting.

Fig 4: The two sides of the Wassergasse in Vienna display different structuring and information density; a configuration of a ground floor that enables interaction with the public space, and one that makes interaction impossible © Tobisch

Conventional urban maps portray only the public space but do not give any information beyond the building perimeter. But apart from the design of the public space itself, the ground floor of the adjacent buildings is the major factor of the perception of the city form a pedestrian's point of view.[9] This includes uses as well as the structuring and permeability of the façade that enable interaction between those vital spaces.

4.3.3 Quality of Stay

Walking is not a strictly linear activity and is often accompanied by stopping or longer periods of time staying at one place, consequently streets cannot be considered as places for traffic only, but must also be viewed as a place to stay.[10] Places to stand and sit, and factors like the soundscape, thermal comfort and protection from weather effects need to be taken into consideration. If a high quality of stay is provided people tend to engage into various other activities, which – through witnessing it – encourages more people to engage in activities themselves.[11]

4.4 Distance to Transit

Since walking as a mode of transport is especially practical for short distances, a network of public transport that is both dense[12] and offering frequent service is needed to cover longer distances at any given time. The density of the stations and therefore the coverage of the public transport system can only be determined by taking into account the characteristics of the street network, not by linear distance (see 4.3.1). A high availability of public transport also decreases the dependency on individual motorized traffic; This means

[6] An attractive walking environment can increase the distances pedestrians are willing to walk for travel reasons by up to 70% (Knoflacher 1996, 133) and has an even higher significance concerning walking for leisure. (Gehl 2012, 5)
[7] The width of sidewalks and them being free from obstacles reducing their width is relevant for traffic purposes – i.e. people walking next to each other or passing each other without having to step off the sidewalk – and also for quality of stay. (see section 4.3.3)
[8] Relevant are the visual, auditory and haptic perception of the environment as well as thermal comfort.
[9] The treatment of the public space, the ground floor of the adjacent buildings and private open space as one continuous entity is brought to attention under the concepts of the Stadtparterre (Urban Parterre) (Psenner 2014a, 5) and the City at Eye Level (Karssenberg and Laven 2016, 15)
[10] In Austria obstruction of traffic is prohibited and stopping without cause is not permitted on the sidewalks (§78 StVO) this legal situation shows that the streets are often intended as transit spaces. (Psenner 2017, 76/81)
[11] Research around the standards for quality of stay and the consequential social life has been conducted in various countries and the findings seem to be universally valid. (Whyte 1980, 94; Gehl 2012, 17; Kato et al. 1978, 2-6,38,46-65; Jacobs 1961, 35-37; Jonge 1967, 10–11)
[12] For low rank public transit like busses and streetcars, a distance of 400 meters from the point of departure to the nearest station was found to be tolerable, for high rank public transport like metro and city trains up to 800 meters of walking distance are deemed acceptable. (Walker 2012, 68)

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less moving and stationary traffic, which ultimately improves the quality of the street space and thus the commitment to walking. In addition to public transport, shared mobility and mobility as a service concepts are also suitable to cover larger distances and encourage multimodal mobility.[13]

Fig 5: Quality of stay ensured by places to stand, sit and engage in various activities in different public places © Tobisch

According to the equidistance principle[14] the nearest station of the public transit system or nearest shared mobility vehicle and the parking spot of the private vehicle need to be at least equidistant to the users point of origin to ensure equal opportunity between the different modes of transport.

4.5 Destination Accessibility

There are two different types of Accessibility, firstly local accessibility, which mainly includes destinations that can be reached within a certain walking time or distance, this factor provides information on the walkability of a neighborhood or district. Secondly, regional accessibility, which encompasses all destinations out of reach for pedestrians, and therefore characterizes the connection to other centers or even cities.[15] Polycentric city structures are generally the most successful in providing both local and regional accessibility to all its inhabitants. Effective Accessibility is not often mentioned in walkability studies, but was found to be an important factor during the research. Several design parameters like sidewalk coverage, location of the entrance and barrier free access contribute to that.

4.6 Demand Management

While availability and costs of traffic infrastructure are not directly part of the physical, built environment, they still have a highly significant influence on walkability and are therefore included in this study. There are two control mechanism to decrease individual motorized transport (IMT) and increase pedestrian traffic. The first one is the principle of induced traffic – the increase of availability of traffic infrastructure directly followed by an increase in demand and vice versa.[16] This is true for moving as well as for stationary traffic. The second one is true-cost pricing for IMT.[17] Recent political efforts for the mobility turnaround are now starting to take the external costs of IMT into account with measures like carbon pricing (i.e. in the EU's Green Deal).

A general reduction of IMT liberates significant financial resources that can be redirected into walking developments and increases both the amount and the quality of public space that is available for other road users and for various activities.

[13] While station based shared mobility concepts can be treated similar to public transport considering the coverage of the service—the city of Vienna aims for a bike sharing station within 300 metres and a car sharing station within 500 metres for 40% and 50% of its inhabitants respectively until 2025 (MA 18 2015, 14)—concise statements about the coverage of free-floating models are not possible without site-specific analysis.

[14] (Knoflacher 1996, 214)

[15] Studies have shown that the two types of accessibility counteract each other to a certain degree, the effect of high levels in one category is most significant when the other one is low. (Handy 1993, 58)

[16] (Kent 2020; Knoflacher 1996, 35–37; Thomas 2013, 14; Speck 2018, 108)

[17] This includes the elimination of subsidies both direct (commuter allowance, tax benefits) and indirect (free or low-cost parking, required construction of parking space on private properties) as well as the consideration of all external costs (construction and upkeep of infrastructure, climate damaging emissions, noise pollution and additional costs in the healthcare system). (Frey 2007, 41; Shoup 2005, 2; Lewis and Adhikari 2017)

Fig 6: Public space in a typical secondary street that is primarily provided to stationary and moving motorized traffic; public space in a redeveloped street of the same width that provides space for various travel and leisure activities © Tobisch

A possible third mechanism is the supply of shared mobility as an addition to the already mentioned public transport. It represents a form of individual transport that needs less parking space because it displays higher levels of circulation and also decreases the need to own a private vehicle for occasional use.

4.7 Demographics

Various demographic aspects – like age, gender, educational level, level of income, lifestyle, ethnicity and cultural background - have an influence on walking behavior. Therefore, demographics are considered a confounding variable which means that their collection is important for the subsequent comparability of different places. From a design standpoint, sociodemographic influences are to be considered in an effort to develop structures and public spaces that cater to the diverse needs of various user groups.

5 RESEARCH BY DESIGN

Where:

The chosen research site–Wien Westbahnhof–used to be one of the major stations in Vienna, it is located on the western border of the city center. Its connection frequency was drastically reduced when the main railway station was opened in 2014, so that most of the structure has already been shut down. The Westbahnhofareal–which includes the station itself as well as the upstream track system and several maintenances buildings–covers an area of 0,3 km². It is situated directly in the compactly built and densely populated city center and has fairly good public transport connections. This provides all the necessary conditions for a high level of walkability, which could not be developed from scratch in an area of this size.

A generous perimeter was set for the area to be studied around the Westbahnhofareal in order to determine the status quo in terms of qualities and deficits and to locate possible effects on the site itself.

Setting:

The development of a framework for a walkable environment on the Westbahnhofareal was based on the findings of the literature analysis. Since the D-variables correlate heavily, parameters for each variable were put in place, analyzed and tested against interdependencies with the other variables and adjusted accordingly afterwards. The resulting iterative process of design, analysis and redesign considered all design benchmarks that influence walkability from the beginning of the planning process.

Stadtparterre–Urban Parterre:

The urban parterre–i.e. the zone that describes the parterre of the city and includes the ground floor, street space and inner courtyards (Psenner 2014a)–is given special attention in the chosen approach. Not least because recent studies have proven its undisputed relevance for the urban system. (Psenner 2021) It plays a special role with regard to the walkability aspect. In the extended study area, the given zoning was compared with the actual use of the ground floor zone and no significant correlation was found. Which suggests that the current system of zoning does not have a significant impact on actual use and therefore may not be the right tool to ensure functional diversity. In addition, the problem of under-utilization on the ground floor and vacancy is prevalent.

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Fig 7: left: Zoning Plan of the Westbahnhofareal; right: actual ground floor uses (colour codes indicating different attractor uses like public, retail, business etc./non-attractor uses marked in grey) © Tobisch

The distribution of public space in the perimeter is characteristic for Vienna, most of the surface area is designated to IMT, both moving and stationary. Typical Streets are transit streets and offer low-cost parking continuously on both sides of the street.[18] With few exceptions, the streets dedicate more than half of the available space to cars, some even up to 80%[19], the remaining percentage is split between pedestrians, cyclists, public transportation and a few trees and leaves little to no room for activities other than traffic. Against this background, the urban parterre in its current state cannot be considered suitable for a walkable city.

5.1 Design

Since the chosen area poses several challenges – i.e. a remaining train connection, a steep topography and, as a local air channel, far reaching importance for the urban climate – and exhibits deficiencies – i.e. insufficient connection of the southern and northern part of the district – a design that increases both walkability on the site itself and provides improvements for surrounding area was pursued.

Thus, the existing street network and block size were taken into consideration when developing the corresponding counterparts on the site. The continuation of streets through the area was ensured wherever possible and additional paths were introduced where necessary, to provide optimal pedestrian connectivity. The building blocks were aimed to be 60-90 meters in side length to provide frequent route choice while still keeping the blocks big enough and suitable for building arrangement that can accommodate various functions as well as reasonable courtyards.

A large park located in the middle of the Westbahnhofareal keeps the local air channel intact; its vegetation provides an additional cooling effect on the urban climate; and moreover, it compensates the general lack of green space and space for recreational walking, sports and relaxation in the area.

Fig 8: left: Site plan, the block size provides frequent route choice and the park provides cooling and space for recreation; right: The pedestrian network provides optimal connectivity considering the topography and remaining train connection © Tobisch

The coverage by public transport is considered suboptimal for both, high and low rank traffic. Consequently, the designed street network is optimized for transit access and two additional stops are added to an existing

[18] Low cost on-street parking is in high demand, while more expensive parking facilities on private property and in garages are underutilized.

[19] Only exceptions found in the area are streets with public transportation and the few existing pedestrian zones.

bus line to ensure full coverage on the site and its surrounding area. In addition, a mobility concept for IMT and shared is developed. Collective garages located in close proximity to public transport stations represent the only parking possibilities for private cars and thus ensure equidistance.[20] Three shared mobility points are introduced to provide adequate alternatives to car ownership.

Fig 9: Isochrone map for low rank public transport for 200 and 400m distance, left: Status quo, right: Design © Tobisch, Hetzenecker

The top priority for the street design was a (re)distribution of the public space in favor of pedestrians and other non-motorized road users. They are not meant to be used for traffic only but also for lingering, therefore, all streets (with one exception) are residential streets. Seating, trees, water elements, bicycle parking and additional free space for various other activities invite residents and passersby to make the street a space to be lived in. Generally, one-way car access is limited to supply and delivery, there is only a single two-way transit street in the area which is sufficient to facilitate both access to the collective garages and the operation of public transport.

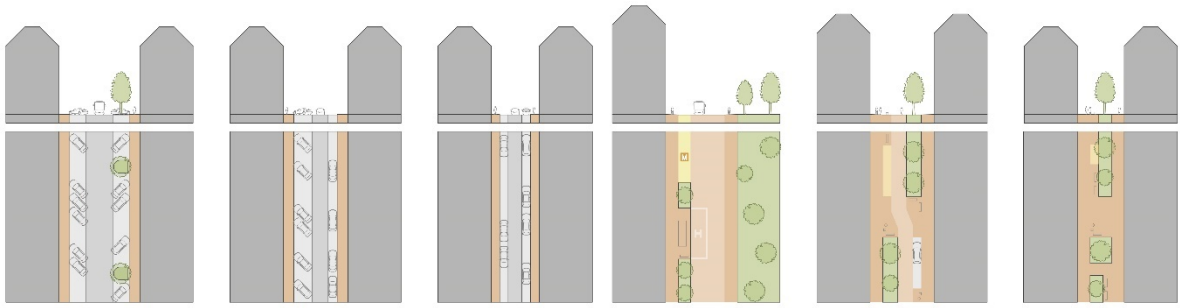

Fig 10: left: Status quo – more than 50% of the space in the streets is designated to stationary and moving IMT, right: Design – all new streets are designed as shared spaces that offer seating, trees, bicycle parking, generally limited one-way car access is possible, streets with public transport are two-way transit streets © Tobisch

Considering the size of the area and walkability as the only design objective for this study the results of planning further qualities to detail without additional data[21] would tend to get more arbitrary than scientific. Therefore, implementation of further planning steps was not carried out to detail but rather formulated in a list of qualities that includes: the positioning of buildings at the edge of public space, pedestrian pathways, semipublic courtyards, small plot size, visual and haptic permeability of ground floor façades, small size of functional units, treatment of ground floor as semipublic space (Psenner 2018), structuring of façades, arrangement of uses and seating in public space.

5.2 Comparison to Historic Structures

Since historic inner-city centers are what walkable environments mostly look like at the moment, the comparison of results of the design process conducted here and those known walkable structures were of interest. The designed structure offers wider streets and intends for generous semipublic courtyard areas with a direct connection to the public space, but the indisputably most notable difference is green spaces and vegetation. It is known that the high degree of sealing in traditional city centers causes a micro climate that is not compatible with the thermal comfort of pedestrians needed for high walkability – even more so in

[20] This does not comply with legal requirements in Vienna, which call for the construction of parking spaces on the property, the amount of parking spots required is derived by the use of the building and the square meters of floor space.
[21] Additional data might be objectives on an urban level (i.e. regional centers), target values (i.e. for uses like social housing, or population and jobs created) or specific uses on a block or plot level (i.e. schools, event locations) etc.

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Vienna, where the 19th century city structure was mostly laid out without any trees at all. (Psenner 2021) Therefore, the developed structure offers trees in every street and a generous large park both for a cooling effect on the urban climate and as a place for recreational walking, sports and relaxation for the residents.

5.3 Learnings form the Design Process

The hypothesis that walkability can only effectively be established when it is considered at all planning steps was confirmed during the planning process. Which also means that existing structures cannot reasonably be adapted to reach the all mentioned qualities, though significant improvements are possible. Walkability as a concept is highly adaptive, deficiencies in some aspects can be compensated for by providing other qualities (i.e. steep topography limits the reach of pedestrians but can provide interesting views). It is quite clear though, that compensation of deficits is only possible to a certain point and potentially not for all aspects that contribute to walkability.

5.4 Weaknesses and Problems

Although the D-variables are highly influential on the walkability of urban environments, they are not properly differentiated from each other and correlate heavily. Therefore, it is not possible to assess the relevance of each one of them separately and quantify their precise influence on the walkability of a built environment.[22] In this study several aspects that are not originally included in certain variables have been added to draw a more complete picture of all of the influences on walkability.[23] Green spaces and trees are scattered through several of the D-variables and might therefore be easily overlooked. Given the great importance of vegetation for walkability (in atmosphere of surroundings, leisure walking, sports and relaxation, micro and urban climate) this can be considered a genuine flaw.

While the D-variables are highly usable when analyzing existing structures and categorizing research, they did not provide a linear framework for planning, the design process was therefore conducted in an iterative process of design, analysis and redesign along the various benchmarks but with the D-variables also in mind.

Several of the mentioned needs of pedestrians do not correspond to the legal situation in Vienna. This mainly involves the use of the street as space to linger, ground floor use and zoning in general, and the construction of parking space. (Psenner 2014b) In some instances, the appropriate tools to ensure a pedestrian friendly development are not available, i.e. when it comes to the permeability of ground floor facades. The implementation of walkability-concepts can therefore only be successful if appropriate policy changes are made.

6 CONCLUSION

The conducted scientific literature research and research by design process revealed that the theoretical knowledge on walkability can indeed be applied in a practical design process. The D-variables proved useful in categorizing the abundance of established and new research material and the resulting theoretical knowledge. They also provided a guidance for the subsequent translation of the research results into parameters for the design of walkable built environment. However, they do not represent the precise perimeter or the design of building blocks with which a walkable city can be assembled, but rather need to be understood as the foundation on which a creative design process can subsequently unfold.

The findings clearly unveil the qualities of a walkable city. Since the needs of pedestrians include structural, functional and qualitative design parameters and relate to all design benchmarks, walkability can only effectively be established when it is considered at all planning steps. Generally, structures must be designed to be functional and comfortable and offer a high quality of stay to encourage walking, but because walkability as a concept is highly adaptive, given deficiencies in some aspects can be compensated for by providing other qualities. The urban parterre plays a special role in regards to the walkable city since the street space and the ground floor of the adjacent buildings are most directly perceived while walking. Its functioning is highly dependent on the legal situation; therefore, the planning of a walkable city can only be successful if the appropriate policy changes are made.

[22] The shortcomings of the D-variables as found in this study have been addressed before. (Handy 2018)
[23] This deficit stems from the origin of the D-variables in transportation research, where parameters like quality of stay are not paramount.

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