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Walking to a public transport station

Empirical evidence on willingness and acceptance in Munich, Germany

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Abstract

Purpose – The purpose of this paper is to explore the actual walking distance to public transport (PuT) stations and to report passenger perceptions on route choice.

Design/methodology/approach – A systematic case study has been conducted after administrating a tailor-made paper-based intercept survey in a German city (Munich). It can determine the interrelation between the accessibility of the transit service and evaluation on walking distance acceptance. Statistical analysis and geo-spatial approach were completed for obtaining major findings.

Findings – Statistical and geo-spatial analysis shows that respondents living in low-density areas walk longer than residents living in nearby inner city areas. In terms of PuT modes, residents walk longer for suburban train and subway/metro (U-Bahn) than for bus/tram services. Transit users accept a longer walking distance to reach a train station than other PuT modes and they choose the most direct and quickest route to reach PuT stations.

Research limitations/implications – Findings of this study would help to formulate future strategies and standards for the sustainable planning of public transportation systems in the context of Munich and many other cities around the globe with similar conditions. However, future research should be conducted using a large-scale survey for evaluating the comprehensive picture of walking patterns to PuT stations. Accessibility to PuT stations can also be modeled and evaluated by adopting open data and voluntary social media information. Unfortunately, this study only presents a partial evaluation of walking focused on accessibility at selected PuT stations in different settings of the urban fabric.

Social implications – This empirical study can be considered as an initial finding in the favor of the city transport authority to provide a design scale for improved accessibility of transit users; however, further investigation should be conducted using a large-scale survey for evaluating the comprehensive walking patterns.

Originality/value – A systematic case study has been conducted after administrating a tailor-made paper-based intercept survey in a German city (Munich). Findings of this study would help to formulate future strategies and standard for the sustainable planning of the public transportation system in the context of Munich and many other cities in the globe with similar conditions.

Keywords Spatial analysis, Accessibility, Urban structure, Urban fabric, Public transport, Walking behaviour

Paper type Research paper

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1. Introduction

Walking is one of the common modes of accessing urban services including public transport and therefore it can largely influence the dynamics of public transport (PuT) infrastructure (Tolley, 2016). An optimum walking distance to the transit stations or points of interest is a significant input parameter to determine users' satisfaction with the overall urban transit system (Givoni and Rietveld, 2007; Woldeamanuel and Cyganski, 2011). For a European city context, a uniform walking distance to a PuT station (i.e. 5 min or 477 meters to a bus or tram) can be assumed for measuring accessibility; however, this threshold may vary depending on the dynamic urban density structure (Poelman and Dijkstra, 2015). The physical activities (i.e. walking or cycling to stations) associated with public transport help in achieving lower body mass index and transit users are less likely to be obese (Martin *et al.*, 2015; Sun *et al.*, 2017). In fact, improved walking facilities to transit stations may not only contribute to reduced traffic (may even increase transit ridership), but can also facilitate a healthy urban lifestyle (Pucher and Dijkstra, 2003; Southworth, 2005). However, walking is often neglected not only as an individual (non-motorized) mode of transport, but also as part of the inter-modal chains during the planning and processing of public transport implementation. Often, the empirical evidence is unclear or there is no consensus regarding the planning assumptions on walking distance to PuT stations. So, there is a demand to explore whether transit users' walking patterns confirm the assumed threshold during planning, including their willingness to walk to access public transport facilities within dynamic urban fabrics.

The aim of this paper is to explore the actual walking distance to PuT stations and to report passenger perceptions on route selection. A systematic case study has been conducted after administrating a tailor-made paper-based intercept survey in a German city (Munich). It can determine the interrelation between the accessibility of the transit service and evaluation on walking distance acceptance. Findings of this study would help to formulate future strategies and standards for the sustainable planning of public transportation systems in the context of Munich and many other cities around the globe with similar conditions.

Walking not only facilitates eco-friendly transportation, but it also has social and recreational value (Southworth, 2005). Therefore, comprehensive research on walking behavior in different settings is needed. The sample PuT stations were selected from dynamic urban settings as suggested by the theory of urban fabric (inner city, functional built-up and suburban areas). This research has also focused on individuals' perceptions to decide their route in terms of trip purpose and mode choice, based on different socio-demographic aspects. The findings of this research aim to reduce the gap between the transit users' view and planning aspects to add new elements for the improvement of future public transport systems.

This paper begins by introducing the scope of walking in the city and a critical review of sustainable urban public transportation planning. The Methodology section includes a short description of the study area, empirical study design, data collection and analytical approach. The major results are presented according to case study results followed by a conclusion which includes policy implications.

2. Related works

Resource-efficient urban structure strategies should focus on accessibility to urban public transportation for diverse groups of city dwellers with several sets of sustainable transport options (Poelman and Dijkstra, 2015; Sikder *et al.*, 2016). To do so, the topic of urban density and the causal relationship of public transportation and land use are already well developed and widely discussed in academic literature (Newmann and Kenworthy, 1989; Holden and Norland, 2005). The relationship between walking distance and the attraction of public transport has already been investigated in Germany since the 1970s (Walther, 1973) and also dealt with the effects of service quality in term of frequency (Walther, 1991). Knoflacher initiated various surveys on the influence of quality and structure of urban space on the acceptance of walking distances (Peperna, 1982). The theory of urban fabrics gives systematic insights with related elements, functions and qualities. Accordingly, sustainable transportation planning can have huge implications due to the associated scale of urban fabrics: walking, transit and automobile (Newman *et al.*, 2016). Saghapour *et al.* (2016) formulated a Public Transport Accessibility Index and proposed a GIS-based approach that included density function as an integrated parameter for planning public transportation services. Lin *et al.* (2014) conducted a fine-scale spatial analysis of transport station accessibility for elderly people in Perth (Western Australia). They adopted the intercept survey approach and calculated a composite index where walking to the station is one of the significant variables besides land use diversity, quality of service, route direction and connection to bus stations.

Knowledge-based urban development is a policy focus in the potential development of global cities that largely depend on intellectual capacity rather than other resources (Powell and Snellman, 2004). Not all types of cities are equally competitive in establishing a knowledge-based economy (Yigitcanlar and Velibeyoglu, 2008). Accessibility and quality of life are key analytical scales to measure progress toward a knowledge-based city (Van Winden *et al.*, 2007). In this regard, open data sources are highly relevant for evaluating accessibility and optimizing public transit parameters in order to improve the quality of services (Lantseva and Ivanov, 2016).

Within the integrated land use transportation model, walking accessibility plays an important role in designing urban public space in a sustainable way. There are six criteria to evaluate a walkable city design such as – connectivity, link to other transport modes, fine gain land use pattern, safety, quality of path and path context (Southworth, 2005). Taleai and Taheri Amiri (2017) proposed a multi-criteria assessment-based hybrid framework where they also included greenness, a line of sight and shading area for evaluating walkability at the street level. Yan-yan *et al.* (2016) proposed a new concept called area public transit accessibility that allows the accessibility level for location optimization of the public transit network to be quantified. However, there are further scopes of empirical investigation to link walking and public transportation, which may contribute to understanding the decision of walking to stations based on diverse urban fabric elements such as density, model connectivity, walking distance, trip purpose, modal split and socio-economic status.

To improve transit users' accessibility, planners need to assess systematically the configuration and environment of walking routes (e.g. distance optimization, aesthetics) approach to stations (Lantseva and Ivanov, 2016). In modern urban and transport planning guidelines, the average walking distance defining the catchment area to a transit stop is usually defined by "rule of thumb" and thus there are different values or parameters for the same purpose in different countries. A common assumption is 400 to 800 meters' walking distance or 10–15 mi of walking time in order to design a transit service to be reasonably accessible. All stations or stops are assumed to be comprehensive for a given mode and this is not true for all aspects (Larsen *et al.*, 2010; Daniels and Mulley, 2013). For example, Yigitcanlar *et al.* (2007) assumed a walking distance of 300 meters and 10-min duration in an Australian city context and proposed four categories of city level accessibility index (ranges 0–1). Critics have also discussed the assumption that all stations or stops are to be comprehensive for a given mode; however, a one-size-fits-all solution to determine catchment areas is unlikely to be effective (Chia *et al.*, 2016). The empirical origin of these commonly used rules of thumb is unclear or there is no consensus with real evidence of the actual walking distance. Therefore, it is yet to be found whether individuals walk within the assumed threshold or they walk further, or how this catchment area affects the decision of travel to the desired stations or service points. Consequently, here is a clear question:

RQ1. How far are people willing to walk to access public transport facilities?

In search of an answer to this question, a case study was conducted for the City of Munich, Germany. The following section outlines the associated method, materials and analytical approaches.

3. Methodology

3.1 Context of Munich

Munich is one of the cities in Germany that possesses an extensive and smooth transit system, but continuous improvement is desirable to ensure a sustainable transit system in the long run. According to the Munich Transport Authority (MVG), the modal split for mobility without a car is around 68 percent and within that 25 percent make their trip completely on foot (Pötzsch, 2014). Additionally, most of the trips made by public transport include walking to public transport stations and stops. Hence, walking is also very important in inter-modal travel chains. According to the transport plan for the city of Munich, the service area of the central business district for subway stations is 600 meters, and it is within 300 meters for the tram and bus. The service area for the tram and bus is considered to be 400 meters within the zone with the high dense area. In the low dense area, the service area is nearly 1,000 meters for a subway, and 600 meters for a tram or bus (CityMunich, 2006). Though transport and land use planners use these parameters, the empirical evidence for such values remains unclear. There has been a study on how long it takes to walk for a single trip for any purpose (Belz *et al.*, 2010), but the willingness of users to walk to a public transport stop within the guided threshold has not been evaluated. During interviews conducted to obtain expert opinions for this research, it has been stated by the Department of Urban Planning and Building Regulation of the city of Munich that there is no existing survey as a supplement to these guidelines for a public transport service area. The decision is made based on an external expert opinion accompanying the guideline for public transport planning in Bavaria with suggestions from MVG or the Munich Transport Corporation (CityMunich, 2006).

The city public transport plan was based on two major planning assumptions: lower urban density leads to a bigger catchment area; and people walk farther to a subway/suburban train station than to a tram/bus stop (CityMunich, 2005). This research conducted a reality check of such assumptions on the basis of systematic empirical evidence.

3.2 Selection of the station

The theory of urban fabric suggests three scales (i.e. an inner city area – walking zone, service area – transit zone and low-density suburban area – automobile zone) that may explain the urban structure and dynamic transportation relation (Newman *et al.*, 2016). The sample PuT stations (survey locations) have been selected according to urban fabric settings and MVV (Munich Transport and Tariff Association) service area zonal divisions. Figure 1 shows ten important stations that were carefully selected by following some specific characteristics such as: an inner city area (Sendlinger Tor, Max-Weber-Platz, Muenchener Freiheit, Arabella Park); a service area that is a residential/commercial area (Moosach, Neuperlach Sued, Giesing); and a suburban area (Ismaning, Deisenhofen, Haar). The PuT modes considered within these stations were bus, tram, underground railway (U-Bahn) and city rapid railway (S-Bahn). The survey excluded all night lines and trips using other modes such as by car, bicycle and others.

3.3 Data collection method

A face-to-face survey or intercept survey is one of the appropriate methods to obtain quick feedback and good data quality within a limited time (Richardson *et al.*, 1995). Lin *et al.* (2014) also effectively adopted the intercept survey method for evaluating accessibility to train stations. This study also conducted an intercept survey with 500 transit users. The random sampling process was adopted for respondent selection; however, a question may always arise on the determination of an appropriate sample size that represents a certain size of the population and expected response rate. In this regard, it is often said that bigger samples

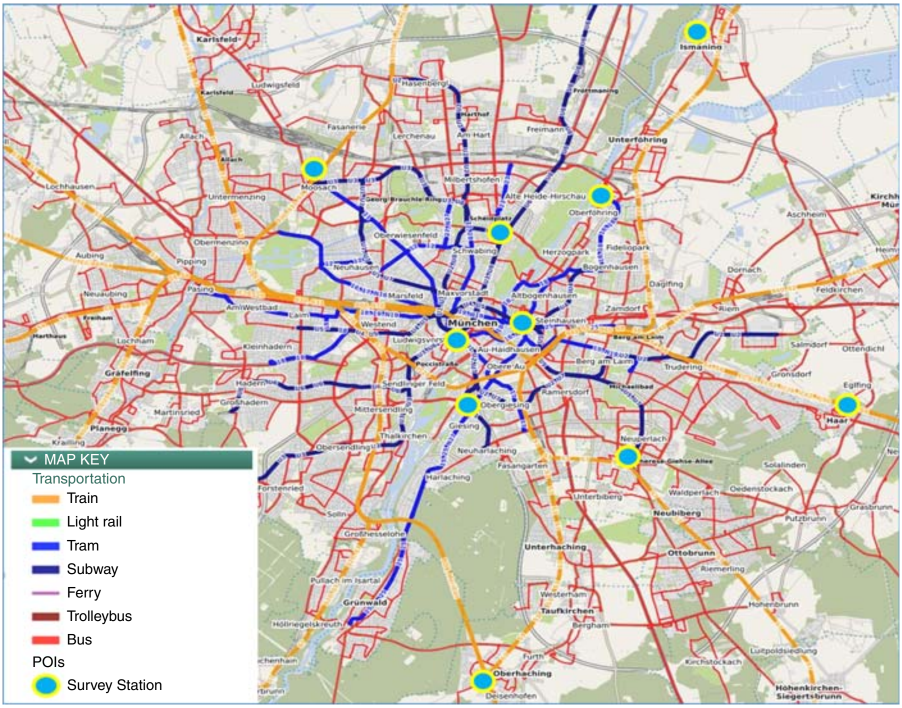


Figure 1.
Suburban and underground train network in Munich

Source: OEPNV- öffentlicher Personennahverkehr Karte (2018)

are better but not mandatory – it is not always possible to cover large sample sizes due to resource constraints. According to Krizek *et al.* (2010), "as a very rough rule of thumb, many communities will think that 500 or 600 returned surveys is a good number, although some may be happy with fewer and some want more." As per suggested guidelines to achieve statistical significance by Krizek *et al.* (2010), the margin of error is accepted between ± 4 and ± 5 percent (at a 95% confidence interval); in this research case, the estimated sample size became about 500 in relation to 1.5m total registered inhabitants in Munich. During the survey session at each selected station, the surveyors approached transit users who were walking toward or leaving a station. The survey process was kept completely anonymous to maintain the data privacy of the respondents. In this survey experience, the data quality issues were addressed by administering an additional survey for about 10 percent.

3.4 Designing the survey questionnaire

A tailor-made paper-based questionnaire was designed according to the research model and key parameters (Figure 2). The questionnaire was administered in two parts – firstly, key questions were asked with regard to actual and preferred walking time to reach the PuT station. The actual walking time was requested not only to understand whether a respondent walked within the assumed planning threshold in Munich, but also to investigate the first assumption – "lower urban density leads to a bigger catchment area" within the Local Public Transport Plan of Munich (NVP – CityMunich, 2005). A list of factors can influence route selection to stations, travel purpose and mobility behavior (e.g. type of tickets, mode choice). Questions related to modal choice were included to verify the walking time between modes in order to evaluate the second assumption of NVP – "people walk further to a subway/suburban

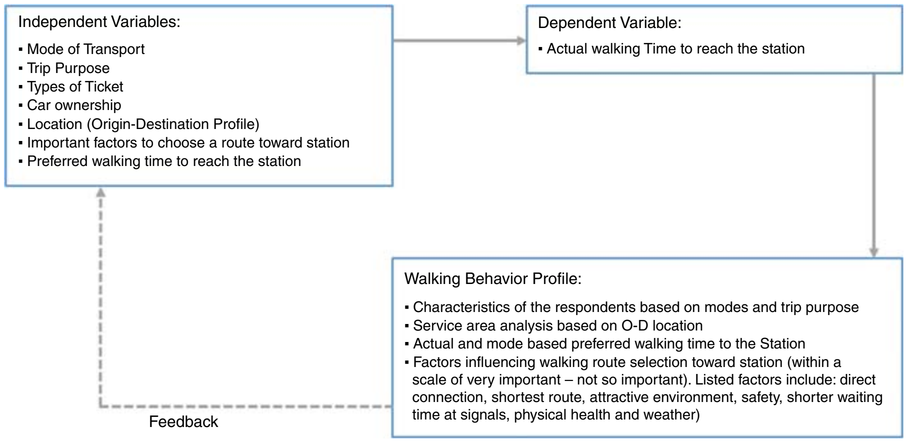


Figure 2.
Research model

train than to a tram/bus." The second part of the questionnaire covered the socio-demographic questions such as age, gender and occupation.

3.5 Duration of survey

The survey was performed during the months of April and May 2014. The survey time at the selected station consisted of 6 h per day including peak hours (morning and evening), off-peak hours and weekends.

3.6 Smart phone application for "plausibility" check

The quality of a public transport facility can be evaluated based on accessibility. An integrated approach of GIS techniques with transportation models can facilitate better communication and decision preparation (Kesik *et al.*, 2015; Gulyás and Kovács, 2016). In this study context, a geo-spatial technology environment such as a digital map was configured on a smartphone app (ESRI-ArcGIS Collector) at the initial stage of the survey. This approach was adopted to collect accurate data on walking time and distance besides the transit users' own responses. The mapping product is available for ArcGIS desktop and compatible with a mobile application via the ArcGIS server. The application can run using an internet connection during the field survey; the data can be collected and edited only with the point features. During the field survey, the map data were created using the mobile application for better visualization of walking routes for the transit users during the survey. Maintaining the privacy of the respondents was also intended, if they did not want to share their exact address but could mark the nearest street to their origin or destination from the specific PuT station. The expectation was to reduce the amount of work and achieve greater accuracy by direct data transfer to the ArcMap desktop via the mobile application rather than manual digitization of locations (point features) mentioned by the respondents.

During the pre-test survey, the majority of respondents were not willing or able to mark their locations on the map due to limited time available at the PuT station – as the arrival of transport modes was very frequent (i.e. U-Bahn). Technically, the application only works with an internet connection and sometimes the internet speed was not sufficient to open and run the application smoothly, especially during the interviews in underground stations (U-Bahn stations). In addition, a compulsory login to use the application for each survey also delayed the data collection process. Apart from that, carrying the smart phone device and recharging the battery every now and then for the whole day seemed to be inconvenient (e.g. the battery of smart phones such as the iPhone last for less time than others). To this end, the low rate of response to the smart phone application along with its initial drawbacks necessitated an additional questionnaire (i.e. the street name of origin or destination).

3.7 Geo-spatial data preparation and network analysis

During the survey, the respondents were asked to write down the address from where they had started walking (e.g. home, office, etc.) toward the station or their address of destination from the station. Nearly half of the total respondents (240 respondents out of 500 respondents) provided their exact street address and house number while the other half did not want to write their address for personal reasons. After collecting the exact addresses, all of the origin or destination points were digitized manually as a point feature used on the ArcMap desktop. The network analysis tool was used to calculate the catchment area of each survey station based on a respondent's point of origin or destination (toward/from the station).

The following section presents the results of statistical analysis (IBM SPSS) and spatial analysis (ESRI-ArcGIS). Following the research objective and analytical approach accordingly formed the key discussion.

4. Data analysis and results

4.1 General findings: PuT modal choice, trip purpose, age and occupation

Among the 500 respondents, the response rate for the U-Bahn was higher. The response rate for bus users was relatively low despite the presence of buses at every station (Figure 3). Among the 500 respondents, the response rate varied according to different age groups. A quarter of the total respondents were aged 46–65. The second highest age bracket to respond was 18–25 years olds (23 percent). The ratio of male and female respondents differed only slightly in percentage (male 44.4 and female 55.6 percent). Regarding their profession, around 52.8 percent of respondents were employed; 24.4 percent were students; 14 percent were pensioners; 3.8 percent were self-employed; and 4.8 percent came under "others." Most of the respondents had monthly and yearly tickets (35 and 29.2 percent, respectively), but the amount of other tickets used (e.g. a multi-ride ticket known as a "Streifenkarte," a day ticket known as a "Tageskarte") was also significant (26.6 percent). It should be noted that the ticketing system in Munich is integrated and one ticket is valid for all public transport modes within the MVV region (Pintscher, 2010). Regarding the trip purpose, recreational activities and shopping remained most significant; total trips made to the workplace were nearly 20 percent; trips to home were 23.2 percent; and educational trips were 6.8 percent. The willingness to walk for recreational activities as well as shopping is considerably longer for most of the age groups than to travel to work/educational places.

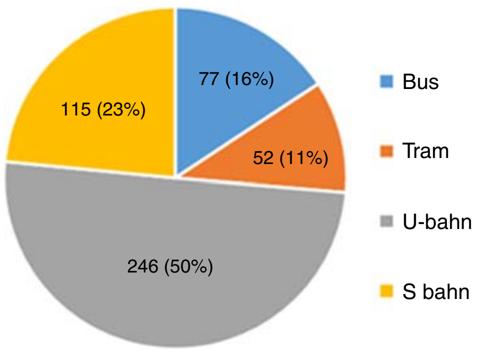
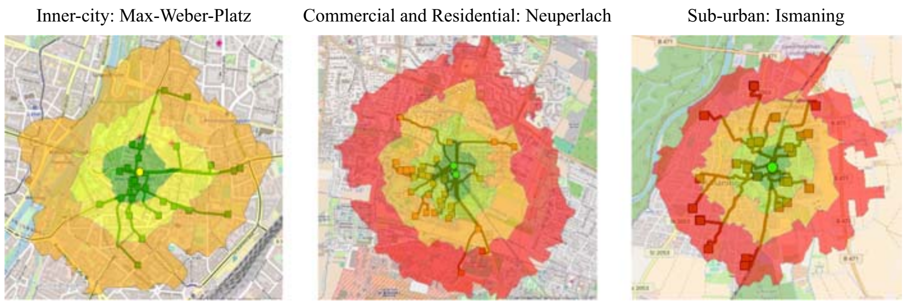


Figure 3. Representation of the number of respondents based on the mode taken during the time of survey by the respondents

4.2 Principle findings (1): lower urban density leads to a bigger catchment area
The geo-spatial analysis shows that the catchment area varied between different categories of stations. For the category of inner city area, most of the respondents walked within a range of 300–600 meters. While, within the category of a mostly residential and commercial area, respondents walked farther than the threshold assumed by planners and their walking range was mostly between 600 and 1,000 meters. On the other hand, in the third category which was suburban areas with low-density of population and less availability of transport modes, most of the respondents walked around 1,000–1,500 meters and even 1,500–2,000 meters at one of the stations (Deisenhofen). Figure 4 shows one example from each category for spatial analysis to evaluate the catchment area of the different stations.

The box plot shows the pattern of observations in terms of distance walked to every station (Figure 5). The walking time to reach the stations in the suburban area ranges between 1 and 25 min, while the walking time for the stations in the inner city area varied



Note: The color shades are showing, respectively, 300, 600, 1,000 and 1,500 meter non-Euclidean distance from geo-location of public transport stations
Source: The open sourced geodata from OpenStreetMap has been used for mapping catchment area; Openstreetmap (2014) contributors

Figure 4.
Example of catchment area analysis

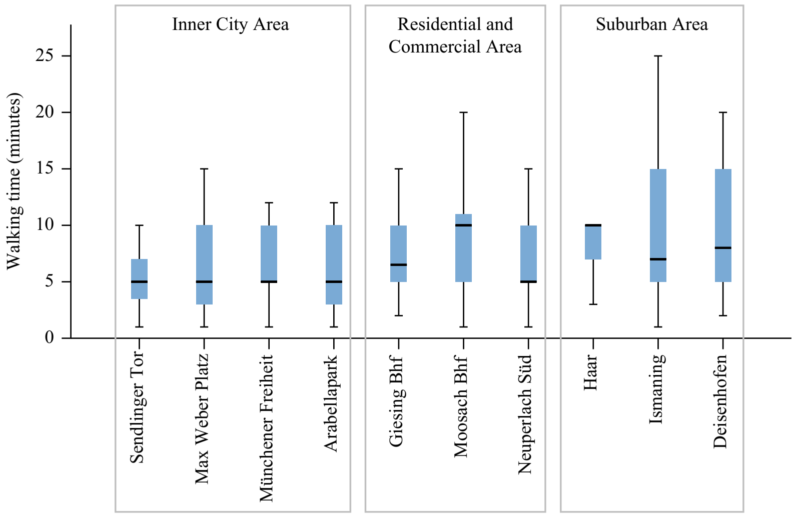


Figure 5.
Analysis of actual walking time (mean) to reach the station without intermediate stop

between 1 and 15 min density. Therefore, from the results above, it is evident that respondents in suburban or low-density areas walked comparatively longer than respondents living or working within the inner city area.

4.3 Principle findings (2): people walk farther to a subway/suburban train than to a bus/tram

4.3.1 Actual walking pattern. In the questionnaire, the respondents were asked to mention their self-estimated walking time from their origin to the station (without any stop) or from the station to a destination. The actual walking time written by the respondents for different modes remained between 1 and 25 min. An individual analysis was performed for each survey station to observe mean walking time for each mode available at those stations. Within the inner city area, on average respondents walked for a longer period of time to a U-Bahn than to a tram or bus, except for the station "Arabella Park" where the mean walking times for the bus, tram and U-Bahn were close to each other (Figure 6). On the other hand, the respondents from the category of different mode choice in the outer city area walked considerably longer for the U-Bahn and S-Bahn than for a tram or bus, except for the station "Giesing" where respondents, on average, walked nearly the same amount of time for the U-Bahn and tram, and slightly longer time for the bus and S-Bahn. Nevertheless, within the suburban area, it was clearly seen that people walked longer for an S-Bahn than a bus.

4.3.2 Preferred walking pattern. The respondents were also asked about their preferred walking time for each mode. Among 500 respondents, most of the respondents answered the question. Nearly half of the respondents (40 percent) said that they were willing to walk for 5 and 10 min for a bus, and less than 10 percent of people said that they would walk for 15 min to take the bus. Generally, respondents in suburban areas on average preferred to

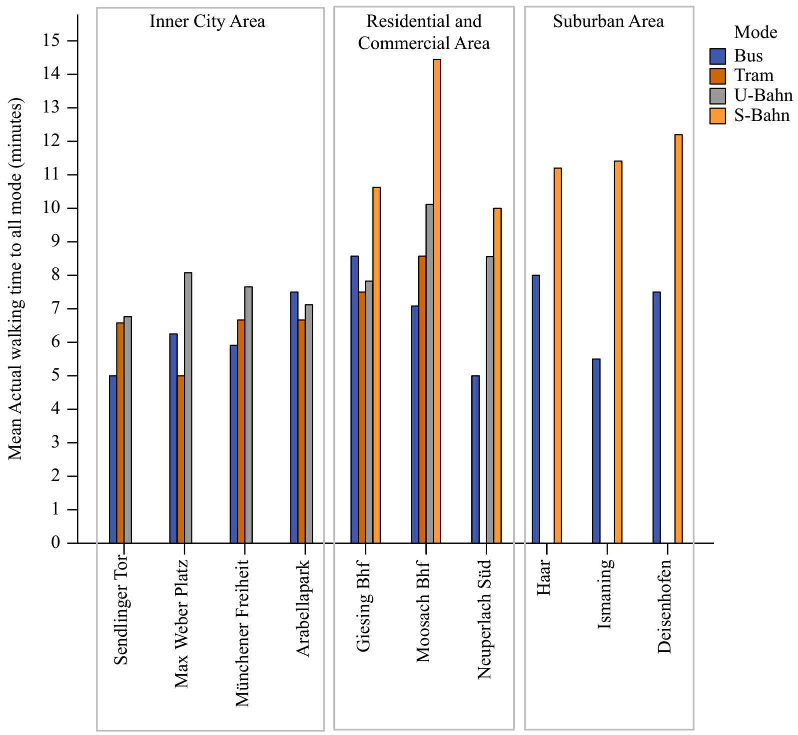


Figure 6.
Mean actual walking time for different modes in every survey point

walk longer for a bus. Apart from that, there was variation in preferred walking time at almost every station. Some respondents would like to walk for only 1–2 min for a bus and some would walk for 15–20 min. Figure 7 shows the difference in preferred walking time at all the survey points. On average, the respondents from suburban areas had comparatively longer time preferences for the U-Bahn than the respondents in other categories. As a reason, some respondents explained that although the U-Bahn is not available in a suburban area, they would accept walking longer for the U-Bahn within the city area as they mostly use the U-Bahn in the city. Regarding the preferred time for the S-Bahn, around half of the respondents (47 percent) wrote that they would accept walking 10 min to take the S-Bahn. Less than 10 percent responded with the walking duration of 20 min. There were also some variations in time preferences below 5 min and longer than 20 min.

A correlation analysis was performed in order to understand what could be the reason behind this preference or why someone would like to walk for so little time and another person would walk moderately longer. The Pearson correlation test showed that the correlation was significant at the 0.05 level (two-tailed) between trip purposes and modes. However, there was no correlation found for age and profession. As an example, the correlation test performed for the S-Bahn and trip purpose is provided in Table I.

4.4 ANOVA and t-test

Statistical tests were conducted in order to verify the results on walking time between modes of PuT to justify the assumptions whether people walk further to a subway/suburban train than to a tram/bus. The distribution of the sample was non-normal, but research evidence suggested that *t*-test and ANOVA are robust to non-normal distribution (Schmider *et al.*, 2010). So, an independent sample *t*-test was conducted to determine if the mean walking time for two different modes (e.g. bus and U-Bahn) was equal. First, it was assumed that "there is no difference between the mean walking times of two different modes." Equal sample sizes for modes were

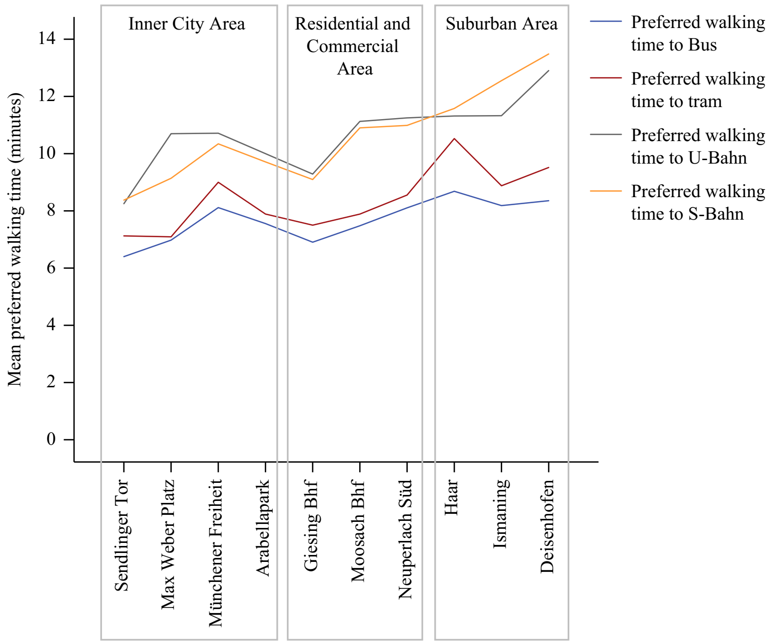


Figure 7.
Variation of preferred walking time (mean) in every station

randomly taken and analysis was conducted for the bus ($n = 77$, mean = 5.22, SD = 2.96) and the U-Bahn ($n = 77$, mean = 7.34, SD = 3.75) and the p-value (by following the guidelines of StatsDirect, 2010) was less than 0.05 (Table II: independence sample test at the row "Equal variance not assumed," two-tailed at 0.000). This test result confirmed that there was a significant difference between the mean walking time of the bus and U-Bahn. Second, another analysis was performed to identify the effect size, and here the value for Cohen's d was calculated to measure the magnitude of the difference between these modes (as suggested in Becker, 1999). The value of Cohen's d was found −0.63 and, ignoring the negative sign, the value was 0.63, which means that there was a large difference in the means between two modes of PuT. It was found to be significant that a transit user walks longer for the U-Bahn than for the bus.

The same analysis was conducted between the tram ($n = 52$, mean = 5.52, SD = 2.91) and the U-Bahn ($n = 52$, mean = 10.96, SD = 5.95) where the p-value was also less than 0.05 and showed that there is a significant difference between these two groups (Table II: independence sample test at the row "Equal variance not assumed," two-tailed at 0.000). The Cohen's d value for this test was found to be 1.16 (ignoring the negative sign), which also showed a large difference between the means of these groups. It can be confirmed that survey respondents walked longer to the U-Bahn than the tram.

The statistical test results for bus/S-Bahn and tram/S-Bahn also found a lower p-value (less than 0.05) and confirmed a similar finding in comparison to the other mode of PuT (Table II: independence sample test at the row "Equal variance not assumed," two-tailed at 0.000). The statistical test indicated that people walked more for a subway/suburban train than for a tram or bus and the stated assumption was supported by the statistical test.

Table I. Correlation between modes (S-Bahn) and trip purpose

Correlations with trip purpose (S-Bahn)	Preferred walking time to S-Bahn	Trip purpose
Preferred walking time to S-Bahn		
Pearson correlation	1	0.112*
Sig. (two-tailed)	–	0.16
n	465	465
Trip purpose		
Pearson correlation	0.112*	1
Sig. (two-tailed)	0.16	–
n	465	465

Note: *Significant at the 0.05 level (two-tailed)

Table II. Result of statistical test with mean actual walking time according to travel mode

		Levene's test for equality of variances		t-test for equality of means					95% confidence interval of the difference	
Mode	Assumed variances	F	Sig.	t	df	Sig. (two-tailed)	Mean diff.	SE diff.	Lower	Upper
Bus and U-Bahn	Equal	10.838	0.001	−3.884	152	0.000	−2.117	0.545	−3.194	−1.040
	Non-equal			−3.884	144.213	0.000	−2.117	0.545	−3.194	−1.040
Tram and U-Bahn	Equal	8.210	0.005	−3.682	102	0.000	−2.731	0.742	−4.202	−1.260
	Non-equal			−3.682	87.544	0.000	−2.731	0.742	−4.205	−1.257
Bus and S-Bahn	Equal	43.809	0.000	−7.361	152	0.000	−5.675	0.771	−7.199	−4.152
	Non-equal			−7.361	110.154	0.000	−5.675	0.771	−7.203	−4.147
Tram and S-Bahn	Equal	25.440	0.000	−5.923	102	0.000	−5.442	0.919	−7.265	−3.620
	Non-equal			−5.923	74.126	0.000	−5.442	0.919	−7.273	−3.612

4.5 Trip characteristics

Trip characteristics and travel behavior play an important role in modal choice. They also influence the preferred walking distance and time for an individual. Walking time to reach a public transport station varies for different professions and age groups according to trip purpose. Within the survey results, differences in walking time were observed in the socio-demographic aspect and trip purpose. Most of the respondents among 500 surveyed reported the actual walking time to reach the station at about 5 and 10 min after considering all the trip purposes; however, for shopping and recreational activities, few respondents even walked for 25 min (Figure 8). The walking time for the same trip purpose varied at the PuT station in different urban fabrics. A longer walking distance was mostly reported for trips to home and shopping/recreational activities at most of the survey points. An exception was found at an inner city station (Münchener Freiheit) where respondents walked longer for an educational trip. People tend to walk a longer distance and for a longer time in all survey locations for an additional trip type (e.g. going to the doctor, post office).

In order to observe how accurately the respondents predicted and estimated their actual walking time, a comparison was investigated between the walking time calculated by ArcGIS and the walking time reported by the respondents. ArcGIS calculated the walking distance as well as walking time (closest facility analysis) with the given walking speed of 5 km/h (e.g. Bettinga and Erbsmehl, 2014) for those 240 respondents who provided their exact address. From the observed difference between ArcGIS calculated time and self-estimated time, around half of the respondents (45.4 percent) among those 240 respondents assumed their walking time very accurately (no time difference or only a difference of ±1 min with ArcGIS calculated time).

4.6 Influencing factors on walking to the station

In order to find out the factors or reasons that influenced the respondents to choose their route and mode, respondents were provided with a list of factors within the questionnaire

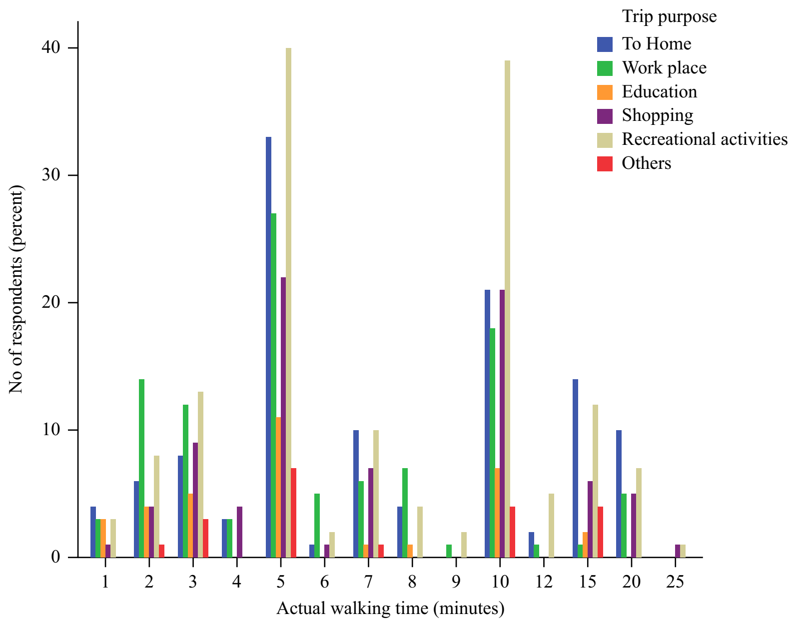


Figure 8.
Actual walking time of the respondents for different trip purposes

that might be important to them. They were also asked about the consistency of their route choice. The factors given within the list included direct path connection, attractive environment, shorter waiting time at traffic lights, shortest distance, health and that they enjoy the walk to the stations. A blank space was included where the respondents could write their own reasons in addition to the list provided. The respondents were asked to rate the list of factors from their point of view on a scale of very important, important, somewhat important, less important and not so important.

The results showed that more than half of the respondents (about 57 percent) took the same route to the station almost every day and nearly three quarters of the respondents indicated "direct connection" and "shortest distance" as "very important" in terms of route selection. The ratings for these two factors are also strongly related in terms of trip purpose and occupation. These findings suggest not only transit user preference for direct connections which should be convenient for their trip purpose, but also considered the route to the public transport station which takes less walking time. In addition, the shorter waiting time at traffic lights on the way to the stations is also an important reason frequently mentioned as a factor for route selection. The respondents were asked if they enjoyed walking to the station and nearly half of the respondents ranked it as an important influential factor for their daily walk to the PuT stations; however, the quality of route and attractiveness of the PuT structure were not clearly detectable within the survey results. The influence of the weather is found to be weaker in walking decision and route choice (more than half of respondents (60 percent) marked it as a less important factor).

5. Conclusions and policy implications

Considering "walking and transit users" while planning is already a popular trend for managing sustainable transport systems. Within the major agency of many European urban authorities, awareness and campaigns are rising to facilitate a well-connected transport network with a transit user-friendly environment and walking cities that could enable a better urban life. Frequently discussed factors are better accessibility, connectivity and safety in order to encourage the use of public transport.

In this research experience, the integrated approach of data collection and analysis was found to be robust for capturing the walking pattern of urban PuT users. The adoption of urban fabric theory (Newman *et al.*, 2016) led to systematic analysis and also the selection of PuT stations from different urban settings. The key results suggested that the PuT users (respondents) walk beyond the assumed walking threshold within the transport plan of Munich in the case of both low-density suburban and high-density inner city areas. Statistical and geo-spatial findings show that the respondents walk a longer distance to reach a train station than a bus/tram station. They would even accept walking longer for a train than other PuT modes. This positive walking attitude was not only reported in a low-density area with the fewest alternative transport modes but also within the inner city area (i.e. high availability of alternative modal choice). Interestingly, most of the transit users enjoy walking to the station. The route preference of walking to PuT stations is highly influenced by mainly two factors: the most direct and the quickest route for their daily travel. Even if they do not use the same route every day, they would still consider these reasons as highly significant. A large part of the respondents are in the working population; therefore, it is practical for them to choose a direct connection and the shortest route for time management. Weather conditions were reported to be a less important influential factor on walking behavior to PuT stations.

This kind of empirical evidence for designing walkable, smart and user-focused future urbanity could be beneficial in the context of better urban accessibility requirements. These study findings can also be taken into consideration by the transport planners to provide design scale for stations in suburban areas with a larger radius for improved accessibility of transit users.

However, future research should be conducted using a large-scale survey for evaluating the comprehensive picture of walking patterns to PuT stations. Accessibility to PuT stations can also be modeled and evaluated by adopting open data and voluntary social media information. Unfortunately, this study only presents a partial assessment of walking focused on accessibility at selected PuT stations in different settings of the urban fabric; further survey including the transit users with walking aid and even accompanied with children can bring an additional perspective. Moreover, one can criticize intercept surveys as a biased data collection method with a random sampling of respondents and selection of stations, but these kinds of limitations can be avoided if the city of Munich authority takes a major initiative with enough resources. Organizations involving professional transport planners, urban designers, land use planners, transit managers and environmental groups could also play an important role in obtaining domain-specific knowledge on accessibility evaluation and for instance – promotion of a walking city. The integration of information technology solutions could also be offered potential advancement, for example, social media and open source data. To this end, these initiatives can assist in accomplishing the motto of "compact-urban-green" for the perspective of Munich (Thierstein and Reiss-Schmidt, 2008) and they can also lead to achieving a degree of the progressive walking city in the European cities.

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