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HOW DO PASSENGER AND TRIP ATTRIBUTES AFFECT WALKING DISTANCES TO BUS PUBLIC TRANSPORT STOPS? EVIDENCE FROM UNIVERSITY STUDENTS IN GREECE

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The spatial arrangement of public transport systems seriously affects their ridership and thus the fulfillment of sustainable transport goals. This paper examines the case of students at Aristotle University of Thessaloniki and investigates their perceptions regarding a critical spatial attribute of public transport, that is, the walking distance they have to cover to/from bus stops when they commute by bus to their campus. A questionnaire survey was conducted to collect relevant data from 300 students and a set of statistical inference methods was employed to explore whether student-specific attributes relate to the walking distances they consider to be acceptable. Empirical findings highlighted weak relationships between user/trip specific attributes with regard to students, and their walking distance preferences for the bus public transport services they use. The majority of students consider that the maximum acceptable walking distance can be higher than the standard value of 400 meters. Moreover, they would be willing to walk more than they currently do in order to reach a bus stop with higher service frequencies to their campus. The study concept and findings could assist in delivering a more successful spatial design of bus public transport systems which serve university campuses. A more sparsely positioned network of bus stops would provide better opportunities for personal physical activity but should not yield increased total travel times; and they should incorporate local user expectations. Public transport agencies could also benefit from achieving higher service speeds which, in turn, would reduce energy consumption and operating costs.

***Key words*: public transport; bus stop; walking distance; spatial design; university students.**

INTRODUCTION

Public transport has been widely recognized as one of the key elements for the sustainable development of modern societies. Worldwide, bus travel remains the most patronized mode of public transport, illustrated by its 63% share of all public transport journeys that were made in 2015 (UITP, 2017). One of the fundamental aspects of designing bus public transport systems is their spatial arrangement. It pertains to the arrangement of bus networks in urban space with respect to the relationships between bus stations, bus routes and the urban environment (Wang *et al*., 2020). Node proximity (distance to the nearest public transport stop/station), network density (number of public transport stops within a 10 min walking distance) and network centrality (mean distance to network nodes by a specific transport mode) are the basic metrics that have been proposed to characterize the spatial configuration of urban transport networks (Gil, 2014). In this respect, bus stop spacing constitutes a critical spatial feature of bus public transport networks, which defines the node proximity and network density. Bus stop spacing also has a major impact on overall travel time, since it affects walking distance to/from stops, along with travel speed, and therefore demand (TCRP, 1996). From the passengers' point of view, walking distance

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to/from bus stops has been recognized as an important factor affecting public transport availability (CEN/TC 320, 2001) because, in fact, public transport is an option for a trip only when the stops are within a reasonable walking distance from one's origin and destination points (TCRP, 2013). Although typical values already exist for deciding such walking distances (FHWA, 2008; UN, 2019 etc.), in practice, the maximum number of meters that a person will walk to a bus stop depends on individual, trip and area specific characteristics such as age, gender, income, trip purpose, pedestrian environment, terrain, and so on. (Alshalalfah and Shalaby, 2007; El-Geneidy *et al*., 2010; TCRP, 2013 etc.). Therefore, the examination of local conditions and population attributes is a prerequisite for designing public transport networks, since unsuitable spatial design decisions may result in inappropriate walking distances and social inequalities, thus preventing certain communities or categories of citizens from using public transport.

This paper examines the perceptions of a certain population group, i.e. university students, regarding the walking distances to/from the bus stops they use for commuting to their campus. University students are generally considered as a relatively young age group with low car ownership rates, who are mostly captive users of public transport (Kobus *et al.*, 2015; Zhou, 2012). This study considers university students at Aristotle University of Thessaloniki (AUTh) in Thessaloniki, Greece. The objectives of this study are to:

- Indicate the walking distance preferences of university students, in terms of the maximum walking distance to/from bus stops which they consider acceptable; and
- Investigate whether certain user-specific attributes (such as gender, income, place of residence) and trip-specific attributes (such as total travel time, trip frequency, trip mode) are related to student walking distance preferences.

The remainder of the paper is organized as follows. The next section reviews the importance of spatial arrangement in public transport networks, as well as typical values and factors which influence the walking distance to/from bus stops. Section regarding the Case Study describes the study area and the data collection process. The data we analyzed, and the corresponding methods, are presented in the Data and analysis section. The results are reported and discussed in section: Results and discussion, and the conclusions are given in the last section.

LITERATURE REVIEW

The spatial arrangement of bus public transport systems greatly impacts mobility patterns, land use development, and the modal split, and thus the environmental footprint of transport systems. In general, the aim of optimizing the design of public transport networks is to fulfil passenger expectations, and it therefore refers to minimizing travel and operating costs, travel time, and necessary transfers, as well as to increasing catchment areas in order to achieve higher ridership figures (Farahani *et al*., 2013). Daganzo (2010) and Badia *et al*. (2014) studied bus public transport network models which would fit the topological and urban transport properties of cities and minimize public transport users' and agencies' costs, while supporting a modal shift from the private automobile. Amiripour *et al*. (2015) demonstrated that the enhancement of bus network designs with genetic algorithm-based methodologies can incorporate experience-based suggestions and reduce the number of transfers required. In terms of urban development, Wang *et al*. (2015) provided strong evidence regarding the positive association between the number of bus stops within walking distance (300m –1500 m) of a property and that property's sale price in Cardiff, UK. Similar findings were also highlighted in the case of Xiamen, China, where the most accessible properties by bus (in terms of distance from bus stops and travel time) were valued comparatively higher (Yang *et al*., 2019). Route spacing, stop spacing and route operating headway have been key variables for determining and assessing the properties of bus public transport networks in past studies (Wang *et al.*, 2020).

With regard to stop spacing, according to the United Nations agenda, convenient access to a bus/low-capacity transport system is achieved when residing within 500 meters' walking distance from a bus stop (UN, 2019). Among public transport practitioners, planners and researchers, a maximum walking distance of 400 meters to reach a bus stop is generally considered as comfortable for all people (Daniels and Mulley, 2013; El-Geneidy *et al*., 2010; Gutiérrez *et al*., 2011; Hess, 2009; Kraft, 2016; Murray and Wu, 2003; Murray *et al*., 1998; TCRP, 2013 etc.). However, empirical findings often prove that this standard underestimates the actual willingness of public transport passengers to walk (Alshalalfah and Shalaby, 2007; Burke and Brown, 2007; El-Geneidy *et al*., 2010; Kramar *et al*., 2015). This happens because, in practice, the maximum distance that people will walk to public transport stops/stations varies depending on the situation (TCRP, 2013). First, passengers seek to minimize their travel time and therefore the duration and distance of the walking segment of their trips (Agrawal *et al*., 2008; Murray, 2003; Pavlyuk, 2015). Secondly, user-, trip- and area-specific characteristics are factors which may also influence the length of the acceptable walking distance. Past research results, however, do not always agree with regard to the list of these factors and the nature of their influence. More specifically, Alshalalfah and Shalaby (2007) studied whether travel and personal characteristics are related to walk access distances to rail and road public transport stops/stations in Toronto, Canada. According to their results, the trip purpose, trip length, age and gender of public transport users do not have a significant relationship with walking distances to/from stops/stations. However, they found that these walking distances are positively associated with household car ownership rates and bus service frequencies. El-Geneidy *et al*. (2010) analyzed more than 37,000 public transport trips in the Montreal metropolitan region, Canada, and observed walking distances to/from bus stops which exceeded the rule of thumb of 400 meters. They used regression modeling techniques to indicate that, inter alia, household car ownership rates, work trips, rail public transport modes, income, students, male travelers and bus service frequencies are positively correlated with walking distances, while the number of transfers, age and return-to-home trips are associated with comparatively shorter walking distances. Jiang *et al*. (2012) highlighted the importance of environment features related to walkability (e.g. safety, comfort, enjoyment etc.) in the walking distances observed for passengers using the bus rapid transit system in Jinan, China. In the same study, trip and trip makers' characteristics, such as occupation, gender, age, car ownership and trip purpose did not significantly affect the walk access distances. Lemoine *et al*. (2016) explained that users of the bus rapid transit system in Bogota, Colombia, regardless of their socioeconomic status and gender, are willing to travel longer walking distances (more than 500 m) to reach the system's stops due to its higher travel speed and quality of service. Wang and Cao (2017) examined the effects of built environment factors on the length of the walking distance covered by public transport passengers in the egress stage of their trips in the Minneapolis-Saint Paul metropolitan area, USA. They employed regression analysis methods and showed that job density, number of stops, land-use mix and intersection density may affect walking distances differently, depending on whether the locations under examination are within or outside downtown areas. More recently, Ragaini et al. (2020) studied the relationship between individual (personal and trip) characteristics and the walking distances to bus stops in Tasmania, Australia using a sample of 944 adults. They discovered that those who walked to more distant bus stops were associated with comparatively greater levels of personal physical activity. Tao *et al.* (2020) analyzed relevant data from the Minneapolis-Saint Paul metropolitan area, USA, and emphasized the importance of spatial attributes, such as population density, job density and intersection density over the traditional socioeconomic and trip attributes, for predicting walking distances to public transport stops.

CASE STUDY

In this paper, the study population consists of the AUTh students who, more or less frequently, commute by public transport buses to the AUTh campus in Thessaloniki, Greece. Thessaloniki is the second biggest city in Greece, with 973,997 residents in its functional urban area (Eurostat, 2020). The city is heavily urbanized, with a relatively high population density of 16,505.4 inhabitants per km^2 (ELSTAT, 2020).

The AUTh campus covers an area of about 33.4 hectares. It is located in a central location of Thessaloniki's functional urban area (Figure 1). Two main arterial roads surround the campus on its north and south sides which enable the campus to be connected with all of Thessaloniki's districts. Use of the land adjacent to the campus pertains to recreational, commercial and residential activities. The AUTh campus includes nine (9) university faculties, with a total of 60,000 enrolled students, making Thessaloniki host to one of the highest proportions of university students in Europe, i.e., 151 university students per 1,000 inhabitants (Eurostat, 2020).

The main travel modes for daily trips in Thessaloniki are: car (41.3%), motorcycle (11.0%), public transport (33.7%), taxi (3.0%), bicycle (1.7%) and walking (9.2%) (MoT, 2019). Public transport services in Thessaloniki are currently provided only by buses, and although during the recent economic crisis period public transport ridership has been increased, the overall quality of services and infrastructure

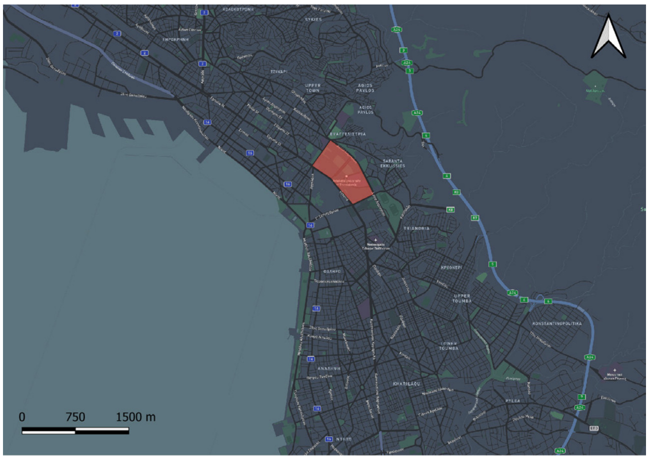


Figure 1. Location of AUTH Campus in Thessaloniki's functional urban area. Map data © Mapbox © OpenStreetMap (Source: Mapbox, 2020)

still needs improvement (Papagiannakis and Vitopoulou, 2015; Verani *et al*., 2015). There are 13 fixed bus lines which offer direct or indirect connections between the AUTh campus and all districts within Thessaloniki's functional urban area. Table 1 presents their service characteristics and classifies them into three categories: (a) main urban lines that provide high frequency connections between the primary transport hubs in the city through main arterial roads, (b) basic urban lines that provide medium frequency connections between the western or eastern urban districts of Thessaloniki and a main transport hub or terminal located in the city center, and (c) suburban lines that are bus feeder services between Thessaloniki's suburbs and a main transport hub or terminal in the city center (Georgiadis *et al*., 2014). Overall, these 13 lines account for approximately 30% of the total annual public transport ridership figures in Thessaloniki (Toskas *et al*., 2013). Their corresponding bus stops, which serve AUTh campus, are presented in Figure 2. Figure 2 shows that these bus stops are located in all main and secondary streets that border the AUTh campus and are well distributed amongst the university faculties. The average bus stop spacing is approximately 250 meters south of the campus and 350 meters north of the campus.

To meet the study objectives, a questionnaire survey was designed and performed through face-to-face interviews with AUTh students. The survey was conducted in October 2015 during the fall semester period. A total of 300 valid interviews were completed.

To ensure a representative sample of responses, a stratified sampling procedure was followed. The required sample of 300 students was obtained from nine (9) strata, in accordance with the AUTh faculties. The size of each stratum was determined by its student population share in AUTh's total student body. This sampling procedure was adopted because while bus stops are common for all students, the walking distances to their faculties may differ. The interviews were based on a structured questionnaire that had three (3) parts. The first part included questions on the personal attributes of the survey participants, such as their age, gender, income and place of residence. In the second part, students were asked about their travel preferences when commuting to/from AUTh. In order to quantify their travel experiences, respondents provided a detailed report on the duration of their public transport trips by bus and distance walked to/from AUTh. In the third part, students shared their opinions on the walking distance to/from bus stops which they consider as acceptable, along with their views on the existing spatial arrangement of bus stops that serve the AUTh campus. The survey questions and results are presented in the following section.

the minimum basic gross salary being 683 euros at the national level (2015 figures) (ELSTAT, 2020). Almost all the respondents were undergraduate students. All categories with regard to place of residence and year of study were represented satisfactorily in the answers that were finally collected. Only a small percentage of students were frequent private car users. The majority of students selected bus as the most frequent travel mode to commute to AUTh. Walking also had an important modal share. This modal split reconfirms past survey findings for the AUTh campus

Table 1. Service features of the bus lines for the AUTh campus
(Source: UTOT, 2020)

Line No	Service frequency (min.)		Mean length of line (km)	Bus size	Line Category
	Peak period	Off-peak			
2; 10; 31	5-10	10-15	~11	Articulated (~120 passengers)	Main Urban
7; 14; 15; 17; 27; 28; 24; 37	~10	15-20	~8	Mostly medium (100 passengers)	Basic Urban
58; 83	~10	15-20	~18	Medium (100 passengers)	Suburban

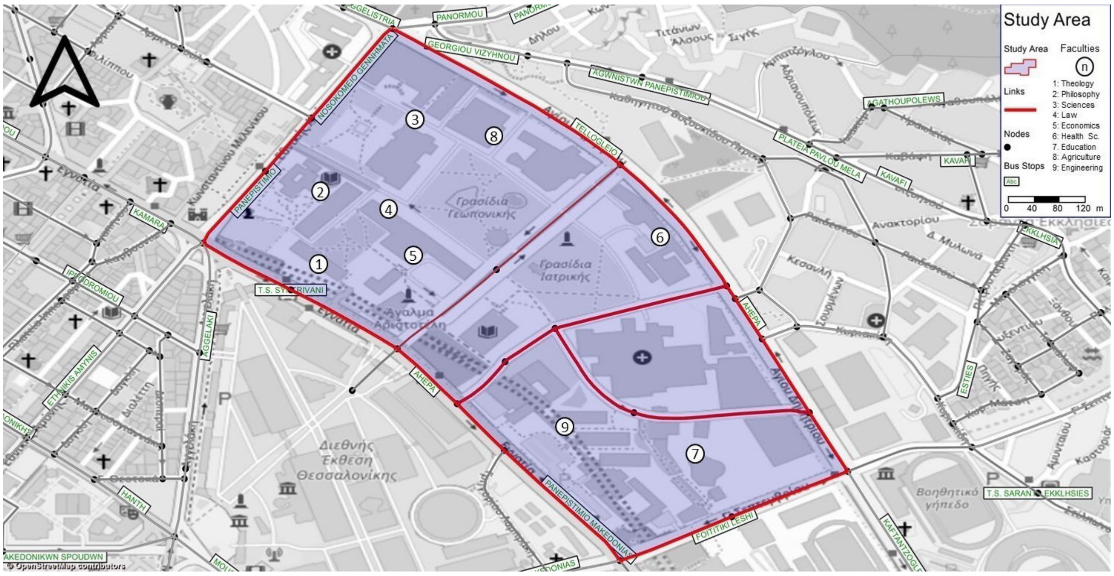


Figure 2. Spatial arrangement of bus stops and faculties in the AUTh campus. Map data © OpenStreetMap contributors, CC BY-SA
(Source: OSM, 2020)

DATA AND ANALYSIS

Data overview

Table 2 presents the dataset we considered for this study. Each survey question (third column) was assigned to a certain variable (second column). In total there were 22 variables that are grouped into three (3) categories (first column). These categories coincide with the three (3) discrete parts of the questionnaire, which were explained in the previous section. To save space, the fourth column of Table 2 summarizes the questionnaire survey results[2].

Table 2 shows that most of the participants were female, belonged to the 18-25 age group and their personal monthly income was less than or equal to 600 euros, with

(Pitsiava-Latinopoulou *et al*., 2013). In most cases, walking time to/from bus stops did not exceed 5 minutes, but walking distances may differ between the first and the last leg of the bus trips. We achieved a satisfactory representation of responses for all the bus stops surrounding the AUTh campus. Regarding walking distance preferences, the maximum acceptable walking distance to/from bus stops mostly varied between 200 and 600 m. In general, students were prepared to walk more to catch a more frequent bus line. Finally, most of them did not think that a modification of the current spatial arrangement of bus stops would provide a tangible reduction to their walking distances.

[2] Full results are available from the authors upon request.

Table 2. Questionnaire survey's variables and statistics

Variable		Question	Answers
USER-SPECIFIC ATTRIBUTES	GENDER	Please select your gender	Male (37%); Female (63%);
	AGE	Which age group do you belong to?	18-25 (95.7%); > 26 years (4.3%)
	EDUC	What is your level of study?	Undergraduate (97.3%); Master's degree/PhD (1.7%); Second undergraduate degree (1.0%)
	INCOME	What is your personal monthly income?	0-600€ (59.7%); 601€-1,200€ (38.7%); Did not answer (1.7%)
	FACULTY	Which university faculty do you study at?	Faculty of Theology (9.7%); Philosophy (19.3%); Sciences (15.7%); Law (8.3%); Economics and Political Sciences (9.3%); Health Sciences (9.3%); Education (6.3%); Agriculture, Forestry and Natural Environment (6.7%); Engineering (15.3%)
	YEAR	What year of your university studies are you in?	First Year (31.3%); Second (18.7%); Third (22.7%); Fourth (14.7%)
	RESID	Please select your place of residence	City center (29%); Eastern city districts (47.3%); Western city districts (23.7%)
	LICENSE	Do you have a valid driving license?	Yes (35%); No (65%)
	CARUSER	If you have a valid driving license, are you the most frequent user of your household's private car?	Yes (13%); No (87%)
TRIP- SPECIFIC ATTRIBUTES	TRMOAR	Which mode of travel do you mostly use to arrive at AUTh?	Public Transport Bus (65.3%); Private car (5.3%); Bicycle (1.3%); Taxi (0.3%); Motorcycle (1.0%); Walking (26.7%)
	TRMODE	Which mode of travel do you mostly use when you leave AUTh?	Public Transport Bus (64.7%); Private car (5.3%); Bicycle (1.3%); Taxi (0.3%); Motorcycle (1.0%); Walking (27.3%)
	FREQ	How often do you perform this trip to/from AUTh? (times per week)	5 times (37.7%); 10 times (48.7%)
	WAKTI1	When travelling by bus from your origin to AUTh, how long (in minutes) do you think you spend covering the distance between your origin and the bus stop?	0-5 (89%); 6-10 (10%); 11-15 (0.7%); 21-30 (0.3%)
	WAIT	When travelling by bus from your origin to AUTh, how long (in minutes) do you think you spend waiting for the bus at the bus stop?	0-5 (51.3%); 6-10 (30.7%); 11-15 (11.7%); 16-20 (5.0%); 21-30 (1.0%); 31-45 (0.3%)
	BUSTIME	When travelling by bus from your origin to AUTh, how long (in minutes) do you think you spend on-board?	0-5 (15.3%); 6-10 (18.3%); 11-15 (23.0%); 16-20 (14.3%); 21-30 (9.7%); 31-45 (11.7%); >45 (7.7%)
	WAKTI2	When travelling by bus from your origin to AUTh, how long (in minutes) do you think you spend covering the distance between the bus stop where you left the bus and the entrance to your faculty?	0-5 (92.7%); 6-10 (7.0%); 11-15 (0.3%)
	WAKDI1	When travelling by bus from your origin to AUTh, how far (in meters) do you think you walk between your origin and the bus stop?	<200 (65%); 200-400 (32.7%); 401-600 (1.3%); 801-1,000 (0.7%); >1,000 (0.3%)
	WAKDI2	When travelling by bus from your origin to AUTh, how far (in meters) do you think you walk between the bus stop where you left the bus and the entrance to your faculty?	<200 (32.7%); 200-400 (63.0%); 401-600 (3.3%); 601-800 (1.0%)
	BUSSTOP	Which bus stop do you mainly use when travelling by bus from your origin to AUTh?	KAMARA (40.3%); PANEPISTIMIO (2%); AHEPA (NORTH) (2.7%); PANEPISTIMIO MAKEDONIAS (8.0%); FOITITIKI LESHI (1.3%); SYNTRIVANI (27.7%); AHEPA (SOUTH) (17.0%); OTHER (1.0%)
WALKING DISTANCE PREFERENCE	WAKDA1	For your usual bus trip to AUTh, what is the maximum acceptable distance (in meters) that you would be willing to walk between your origin and bus stop or between the bus stop where you left the bus and the entrance to your AUTh faculty?	<200 (10.3%); 200-400 (37.3%); 401-600 (34.3%); 601-800 (8.7%); 801-1,000 (3.7%); > 1,000 (5.7%)
	WAKDA2	For your usual bus trip to AUTh, what is the maximum acceptable distance (in meters) that you would be willing to walk in order to reach a bus stop that provides a more frequent bus service to/from AUTh?	200 (20%); 300 (35%); 400 (45%)
	PLACE	Do you think that there is a need to modify the existing spatial arrangement of bus stops around AUTh so as to reduce walking distances between bus stops and the entrance to your faculty?	Strongly disagree (48%); Probably disagree (21.3%); Probably agree (10.7%); Strongly agree (20%)

Analysis setting

In order to analyze the questionnaire survey's results, we quantified, one by one, the variables from Table 2 by assigning a single positive integer to each category of responses collected. The numbering sequence followed the order of appearance that is reported in Table 2 answers. In order to address our first research question, we synthesized the responses we collected from the variables that belong to the "trip specific" and "walking distance preferences" groups. For the second research question, we employed statistical inference methods to examine whether "user" and "trip" specific attributes (Table 2) could explain the walking distance preferences of university students, as these were quantified by the three (3) variables in the respective groups (Table 2). Table 3 presents our initial hypotheses regarding the direction of the relationships between these groups of variables, taking into account the literature review findings and common sense. In short, we expected that the respondents who are more frequent car users, belong to the upper income and age groups and perform bus trips that are comparatively longer in duration (in all or one of their stages) would be associated with comparatively shorter acceptable walking distances to bus stops (WAKDA1 and WAKDA2) and lower satisfaction from the current placement of bus public transport stops (PLACE). The type of variables determined the test statistic we used in each case. When user-specific variables were nominal, Mann-Whitney U (for variables with two categories) or Kruskal-Wallis tests were carried out, while for ordinal variables, Spearman's correlation coefficients were estimated. For all test statistics, the null hypothesis (H_0) we adopted was that there is no relationship between user/trip specific variables and walking distance preference variables. The alternative hypothesis (H_1) is that there is a statistically significant relationship between them. We rejected the null hypothesis for p-values lower than 0.05. All calculations were performed with SPSS software (IBM, 2017).

RESULTS AND DISCUSSION

Maximum acceptable walking distance

Figure 3 compares the current and maximum acceptable walking distances to/from bus stops as reported by the AUTh students who participated in the questionnaire survey. For the majority of the respondents' trips, current walking distances from the points of origin to bus stops (WAKDI1) are lower than 200 meters, and as such they are shorter than the corresponding distances from bus stops to the AUTh faculty entrances (WAKDI2), which mostly range between 200-400 meters. However, the maximum acceptable walking distances for the same trips (WAKDA1) are generally higher, since more than half of the university students (52.4%) would be willing to travel on foot for more than the typical value of 400 meters in order to reach a bus stop that would provide services to/from the AUTh campus. Moreover, if we combine the Figure 3 and Table 2 findings, we conclude that, on average, though WAKDI2 is greater than WAKDI1, WAKTI2 is shorter than WAKTI1, which means that university students develop faster walking speeds when walking inside the campus. This is probably explained by its car-free environment and the fact that students may be in more of a hurry to be on-time for their lectures etc.

The willingness of students to walk further distances than their current ones is also evident in Figure 4. An important share of students (43%) would walk up to 400 meters if they could approach a more frequent bus service to/from AUTh.

Table 3. Initial hypotheses and test statistics used for investigating the relationships between user/trip specific attributes and walking distance preference variables

User and Trip Specific Variables	Walking Distance Preference Variables			Test Statistic
	WAKDA1	WAKDA2	PLACE	
GENDER	Ambiguous	Ambiguous	Ambiguous	Mann-Whitney U
LICENSE	Ambiguous	Ambiguous	Ambiguous	
CARUSER	Positive	Positive	Negative	
FACULTY	Ambiguous	Ambiguous	Ambiguous	Kruskal-Wallis H
RESID				
BUSSTOP				
TRMOAR				
TRMODE				
AGE	Negative	Negative	Positive	Spearman's Rank-Order Correlation
INCOME				
FREQ				
WAKTI1				
WAIT				
BUSTIME				
WAKTI2				
WAKDI1				
WAKDI2				

Figure 4 also shows that opinions are generally in favor of the existing placement of bus stops that envelop the AUTh campus.

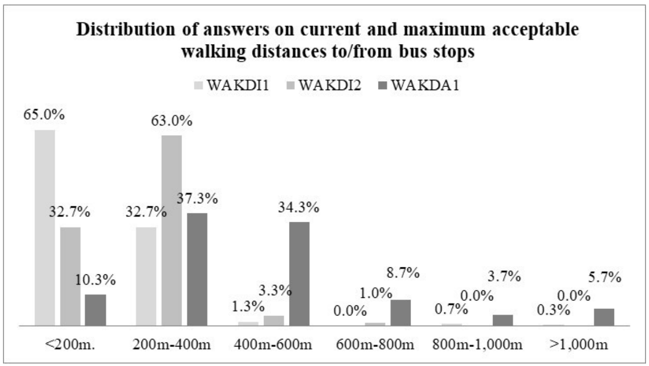
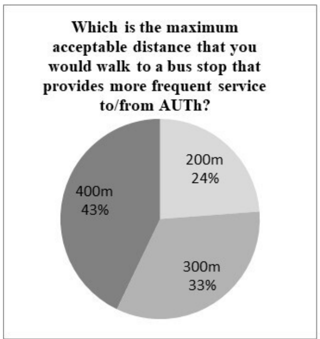


Figure 3. Comparison between current walking distances and maximum acceptable distances to/from bus stops when travelling to/from the AUTh Campus

Overall, the maximum acceptable walking distance for the majority of the university students was found to be greater than the current distance they walk, and higher than the rule of thumb used by public transport practitioners (i.e. 400 m). In line with previous research findings, which emphasized the positive correlation between bus service frequencies and higher walking distances to bus stops (Alshalalfah and Shalaby, 2007; El-Geneidy *et al*., 2010), most AUTh students are willing to walk greater distances, compared to their actual ones, in order to reach a bus stop with more frequent bus services.



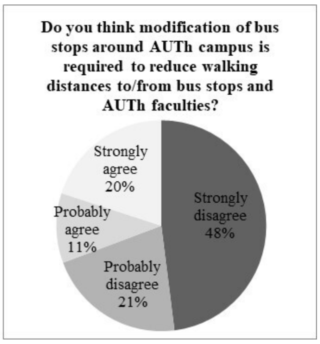


Figure 4. Maximum acceptable walking distances to more frequent bus services (left) and attitudes on current bus stop placement (right)

Impact of user and trip specific attributes on walking distance preferences

In order to investigate our second research question, i.e. whether the above preferences on walking distances to/from bus stops are dependent on specific user and trip attributes, we performed a series of inferential statistical tests, as explained in the Analysis setting. Table 4 presents the Spearman's rank correlation coefficient figures. In almost all of the cases, no user- or trip-specific attribute (first column) is significantly correlated with the three (3) variables that capture the walking distance preferences over the local bus public transport network. Only in three (3) cases are statistically significant correlations found, specifically:

- A positive relationship exists between WAKDA1 and BUSTIME. This means that bus passengers who spend more time on-board are more willing to walk further in order to reach a bus stop. This finding is in contrast to our initial hypothesis and may sound like a paradox. It probably implies that students do not expect comparatively great duration differences among the stages of their bus trips;
- University students for whom bus stops are comparatively more distant from their faculty entrances (WAKDI2) are more willing to walk further (WAKDA2) in order to wait at a stop where they can use a more frequent bus service to/from the AUTh campus. This result disagrees with our hypotheses setting but it emphasizes the relative attractiveness of bus stops where frequent bus lines can be accessed; and
- In line with our initial hypothesis, respondents who were over 26 years old (AGE) are associated with comparatively more statements that asked for a modification on the existing placement of bus stops which surround the AUTh campus (PLACE).

However, though statistically significant, all of the above correlations between variables are very weak, since the corresponding coefficients are lower than 0.2. Therefore, we cannot consider these three (3) user-specific attributes as being critical to the students' preferences on walking distances and placement of local bus stops.

*Table 4. Spearman's correlation coefficients and p-values** for the variables examined*

	WAKDA1	WAKDA2	PLACE
AGE	-0.052 (0.374)	0.046 (0.428)	0.130 (0.025*)
INCOME	-0.085 (0.146)	0.002 (0.967)	0.090 (0.124)
FREQ	-0.076 (0.187)	-0.059 (0.306)	-0.015 (0.795)
WAKTI1	0.017 (0.774)	0.053 (0.360)	0.021 (0.718)
WAIT	-0.047 (0.418)	-0.026 (0.654)	-0.035 (0.552)
BUSTIME	0.133 (0.021*)	0.086 (0.138)	0.032 (0.585)
WAKTI2	-0.016 (0.780)	-0.012 (0.831)	0.072 (0.217)
WAKDI1	0.046 (0.424)	0.092 (0.114)	-0.065 (0.259)
WAKDI2	-0.048 (0.412)	0.149 (0.010*)	0.049 (0.398)

*** (p-values in parentheses)*

Regarding the hypotheses checked against the Mann-Whitney U test, Table 5 shows that the maximum acceptable walking distance to a more frequent bus stop within the female group of respondents is very close to being considered as statistically significantly higher compared to the male group. Possession of a driving license and frequency of private car use did not have any statistically important correlation to the walking distance variables. Similarly, no statistically significant correlations were found for the passenger and trip related variables that were tested by the Kruskal-Wallis test.

Overall, we did not observe any strong or moderate statistically significant correlations between user/trip specific attributes and walking distance preferences. This means that AUTh students, regardless of their personal and mobility characteristics, generally share similar behaviors and perceptions in terms of their walking distances to/from bus stops.

Table 5. Mann-Whitney U output of SPSS for gender and walking distance to a more frequent bus stop

Ranks	**GENDER**	**N**	**Mean Rank**	**Sum of Ranks**
WAKDA2	Male	111.00	138.74	15,400.50
	Female	189.00	157.40	29,749.50
Test Statistic	WAKDA2			
Mann-Whitney U	9,184.50			
Wilcoxon W	15,400.50			
Z	-1.942			
p-value	0.052			

CONCLUSION

In this study we investigated a critical spatial attribute of bus public transport systems, i.e. the walking distance to/from bus stops, which is one of the factors determining the quality of public transport services, and therefore ridership. We carried out a customized questionnaire survey to collect data on the preferences and perceptions of AUTh university students regarding the access and egress walk distances they travel when commuting by bus to the AUTh campus. Then, we employed statistical inference tools to explore any relationship between their individual characteristics and their opinions on the bus stop placement and resulting walking distances for the bus services they use.

Empirical findings reconfirmed past related research results, since they highlighted that in the case of AUTh's university students: (a) the maximum acceptable walking distances to/from bus stops can be higher than the typical value of 400 meters considered suitable for the general public and (b) a more frequent bus service could be a motive for walking further to the corresponding bus stop. Statistical inference results indicated that these walking distance preferences are unanimous amongst AUTh's student body and do not critically depend on their personal and trip specific attributes.

These findings can appropriately contribute to the improved spatial design of bus public transport networks which serve university campuses, since it was made evident that students are willing to accept a more sparsely settled network of bus stops, provided that service frequencies are higher. In practice, higher service frequencies can also be achieved, since the bus speed will ultimately be increased if the space between stops is greater. Improvement in the speed of public transport can also reduce energy consumption, and thus, public transport agency operating costs. More sophisticated planning of bus stop spacing, which incorporates user expectations, could lead to improvement in the quality of service and an increase in the public transport ridership, along with providing opportunities for higher levels of personal physical activity. The challenge, however, is to make appropriate decisions on bus stop locations, which should be withing reasonable walking distances from the main centers of campus activities. These decisions should take into consideration the opinions of university students and the topological characteristics of the areas under question.

The low variability of specific personal attributes of the respondents, such as income, age and degree program, did not allow us to sufficiently examine them under our hypotheses. Since we tried to keep the duration of the questionnaire survey under the reasonable time limit of 10 minutes, we did not manage to collect data and thus explore opinions relating to additional spatial design characteristics, such as bus stop design and environment features relating to walkability. Further research should also explore the spatial arrangement preferences of additional population categories so as to support customized decision-making on the design of public transport networks that will encourage the shift to more sustainable transport means. Finally, given that the survey and findings refer to 2015, a follow-up validation research is probably required to sufficiently accommodate any effect due to the introduction of micromobility transport schemes in Thessaloniki (mostly e-scooters) and COVID-19 restriction measures. Such dramatic changes could have possibly influenced passenger viewpoints on public transport services and attributes, along with significantly modifying their mobility behavior and preferences, either permanently or temporarily.

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