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Residential dissonance and walking for transport

Abstract

The concept of residential dissonance contextualizes the combined impact of built environment and individual travel and land-use preferences on travel behavior. A limited number of studies have explored the effect of residential dissonance specifically on walking. However, evidence from the active travel literature suggests that the environmental characteristics associated with diverse active travel modes differ to some extent. This study addresses residential dissonance in a framework specific for walking outcomes, as the applied neighborhood boundaries, residential preferences and the observed built environment were operationalized with measures related to walking for transport. SoftGIS, a public participatory GIS method allowing the mapping of frequently visited destinations was used to survey the daily walking behavior of 772 respondents aged 25-40 years living in the Helsinki metropolitan area, Finland. Ordinal logistic regression analyses were used to assess the adjusted odds of walking a high share of estimated monthly trips and travel distance. The identified residential dissonance groups were found to have significant associations with the walking outcomes. Associations between the observed neighborhood walkability and the walking outcomes varied by trip purpose, being more consistent with walking to utilitarian than to recreational destinations. Overall, the results support views on the interconnectedness of individual attitudes and the built environment in facilitating walking for transport.

Keywords

Residential dissonance, walking for transport, residential environment, walkability, activity space

1. Introduction

As evidence from the field of housing studies has shown, residential location choice requires the negotiation of a wide range of competing individual- and household-level needs and preferences (Kim et al. 2005a; b). In this process, inhabitants might trade off desired qualities of the residential environment in favor of other qualities with a higher perceived value (Coolen and Hoekstra 2001). Moreover, constraints related to the household's financial position (Jansen et al. 2011), life-cycle (Geist and McManus 2008; Kim et al. 2005b; Vasanen 2012), and discrimination in the housing market (Havekes et al. 2016) may further complicate trade-offs between diverse competing preferences. Considering the complexity of this process and the priority given for instance to housing price and type over land-use preferences (Lee and Waddell 2010; Liao et al. 2015), it is likely that a certain share of urban dwellers are not able to live in residential environments corresponding to their personal preferences. When limited to the physical characteristics of the residential environment and used to explain variation in travel-related outcomes, transportation research recognizes this mismatch as residential or neighborhood type dissonance (Schwanen and Mokhtarian 2004). The concept has been applied in attempt to address residential self-selection (Cao et al. 2009; Handy et al. 2006) and to contextualize the joint effect of the built environment and individual residential preferences on travel behavior. Results to date indicate a significant relationship between residential dissonance and several travel outcomes (Kamruzzaman et al. 2013; Schwanen and Mokhtarian 2004, 2005a; 2005b; De Vos et al. 2012; Wolday et al. 2018).

A limited number of studies have explored residential dissonance in connection to active travel, with most empirical research still conducted in the US, Australia or Canada. Moreover, only a small number of studies, for example Frank et al. (2007) and Cho and Rodríguez (2014), have addressed residential dissonance in reference to walking separated from other modes of active transportation. However, evidence from the active travel literature demonstrates that the environmental measures associated with such active travel modes as walking and cycling differ to some extent (McCormack and Shiell 2011). This is also the case with domain-specific behaviors such as walking and cycling for recreational or utilitarian purposes (Heesch et al. 2015; Saelens and Handy 2008; Sugiyama et al. 2012). As it follows, addressing such contextually situated behaviors with environmental measures specific for the behavioral outcome may improve the validity of the achieved results (Giles-Corti et al. 2005; Saelens and Handy 2008). Health behavioral studies applying ecological models likewise emphasize that the multiple levels of influence affecting diverse health behaviors, such as regular use of active transportation, are best understood in relation to specific behaviors (Sallis et al. 2006; Sallis and Owen 2015). These observations provide compelling support for residential dissonance studies observing active travel behavior to explore frameworks differentiating between diverse domains of non-motorized transport. With respect to walkability-related residential dissonance, this requires identifying and operationalizing the applied dissonance measures in relation to the applied walking outcomes.

This paper has two objectives. First, to develop a framework for assessing walkability-related residential dissonance with dissonance and outcome measures associated with walking for transport in the residential context. This includes proposing residential environment boundaries modelled as local activity spaces as possible means of increasing conformity between residential environment measures and walking outcomes. SoftGIS, an advanced public participatory GIS (PPGIS) method, is employed to enable the refined operationalization of individual environmental exposure. Second, the study examines whether the effect of walkability-related residential dissonance on walking behavior differs from results obtained from non-walking-specific dissonance studies. The empirical part of the study contributes to the field of active living research by examining the associations between residential dissonance and walking amongst young adults in the Helsinki metropolitan area. The likelihood of walking for transport is assessed by the dissonance between the observed walkability of the respondent's residential environment and individual preference for walkable or low-walkable residential environments. Separate analyses are conducted for walking to utilitarian and to recreational destinations.

The paper is organized as follows. Section 2 summarizes the findings of existing residential dissonance research with a focus on recent applications within the active travel literature. Section 3 describes the data and the applied methodology, dissonance measures, and walking outcomes. Finally, Sections 4 and 5 present the results of the empirical work and discuss the key findings.

2. Background

2.1 Residential dissonance and walking

Research has largely confirmed the hypothesis by Schwanen and Mokhtarian (2005b), who suggested that residents that prefer and live in highly urbanized environments are likely to use more public and active transportation than residents who prefer and live in more car-oriented and less urbanized environments. Whereas consistent findings have been reported on the travel behaviors of these consonant groups, less consensus exists on the behavior of dissonant residents, i.e. groups living in residential environments that do not match their expressed land-use and travel preferences (Cao 2015). Findings from non-walking-specific residential dissonance studies in the US and Australia suggest that in both urban and suburban settings, residents preferring high-walkable or transport-oriented residential environments are more likely to engage in active travel than residents with preference for car-oriented environments (Badland et al. 2012; Kamruzzaman et al. 2013, 2016a; Schwanen and Mokhtarian 2005b). De Vos et al. (2012) reported similar results in Flanders, Belgium, observing that urban consonants were the most frequent users of active transportation modes while travelling to leisure destinations, followed by rural dissonants, urban dissonants, and rural consonants. However, the relative importance of the built environment or the residential preference in predicting the travel behavior of

dissonant resident groups appears to be to some extent affected by the choice of outcome measure. Observing the travel patterns of urban and suburban respondents in the San Francisco Bay area, Schwanen and Mokhtarian (2005b) reported that while urban residents used active travel modes more frequently than suburban residents regardless of their land-use preference, urban land-use preference was stronger in explaining the overall distance covered by active travel modes than residential location in urban or suburban areas.

Fewer studies have discussed residential dissonance specifically in relation to walking behavior. De Vos et al. (2012) reported that urban land-use preference increased walking to leisure-time destinations more than residential location in urban or rural environments, whereas frequency of car use was mainly determined by characteristics of the residential environment. Similar results were reported by Frank et al. (2007) who, comparing the shares of respondents walking to discretionary and non-discretionary destinations in the Atlanta region, observed that residents with a low preference for walkable environments walked little regardless of how walkable their residential environments were. Most walking was associated with high-walkability consonants, followed by low-walkability dissonants. On the contrary, Cho and Rodriguez (2014) reported results that emphasized the role of the built environment on both walking for transport and for leisure in the Washington, DC metropolitan area and in the Twin Cities area. In the study area of Washington, DC urban consonants and urban dissonants were more likely to walk than suburban consonants, whereas in the Twin Cities sample a positive association was observed only between frequent walking and the group of urban consonants. Overall, the existing findings on the effect of residential dissonance on active travel and specifically on walking remain somewhat mixed. Comparisons between the existing evidence are likewise hindered by the wide range of methodological approaches used in addressing both residential dissonance and the walking outcomes.

2.2 Defining and operationalizing residential dissonance

In its embedded duality, residential dissonance consists of two main operational components - an estimate of the individual residential preference and an estimate of the residential environment. Studies modeling the level of dissonance between the preferred and actual residential environments generally define residential preferences as instrumental or experiential attitudes towards certain environmental characteristics or behaviors facilitated by these environments. The assumed influence of individual attitudes on human behavior positions the concept of residential dissonance amongst the extensive body of travel behavior research grounded in theories of planned behavior (Ajzen 1991) and emphasizing individual agency as a driver for behavioral change.

The residential environment, on the other hand, has been approached both in terms of perceived and observed environmental attributes. The former are commonly applied in studies emphasizing the effect

of individual environmental perceptions on residential stress (van Ham & Feijten 2008; Fatmi et al. 2017) or on residential satisfaction (Wang and Cao 2017; Jansen 2014; Cao and Wang 2016), while the latter are used in residential dissonance research interested in the effect of the built environment on travel mode choice. Residential dissonance studies with travel outcomes have generally defined the residential environment either as fixed spatial units or as ego-centered neighborhoods. Approaches applying fixed spatial units include comparisons between two or more neighborhoods, census tracts or other administrative units categorized by their level of urbanization or a comparable measure (Badland et al. 2012; Cao 2015; Cho and Rodríguez 2014; Schwanen and Mokhtarian 2004, 2005b; De Vos et al. 2012). The main benefit of these approaches lies in the availability of compatible data on the level of administrative units. However, the suitability of administrative units to reflect individual environmental exposure has been questioned, as they assume equal exposure between inhabitants and cannot be adjusted for the geographical scale most relevant for analysis (Holliday et al. 2017; Howell et al. 2017; Lee et al. 2008).

In recent years, advances in GIS-modeling and in the availability of spatial data have increased the ego-centered modeling of residential environments (Chaix 2009; Perchoux et al. 2013). Residential dissonance studies applying ego-centered measures define GIS-based built environment attributes within a pre-defined Euclidean or street-network distance buffer around each respondents' dwelling location. Kamruzzaman et al. (2016a), for instance, classified respondents' home environments into transit- or non-transit-oriented developments based on public transport accessibility, employment and residential density, land-use mix and intersection density within an 800-m network distance buffer. Frank et al. (2007) divided respondents into walkability quartiles based on the observed walkability within a 1-km network distance buffer and applied a walkability measure combining commercial floor area ratio, land-use mix, net residential density and street connectivity. Recently, Wolday et al. (2018) identified respondents residing either in transit-rich or transit-poor areas based on distances between the dwelling location and nearby urban centers. While the ego-centered models based on equal buffer distances provide a good general measure for the local residential environment, they are likely to overestimate the use of some areas and underestimate that of others when addressing behavioral outcomes (Perchoux et al. 2013). To overcome these problems, neighborhood boundaries based on individual mobility patterns have been proposed as possible alternatives for the ego-centered models (Hasanzadeh et al. 2018; Holliday et al. 2017). The home range model (Hasanzadeh et al. 2017) applied in this study is a recent example of an individualized neighborhood boundary model that approximates the local activity spaces of everyday use. Estimating the neighborhood extent frequented by each individual, neighborhood boundaries based on this model provide a viable option for assessing the support residential environments provide for habitual walking.

3. Research materials and methods

3.1 Data collection and methodology

The data collection was executed using SoftGIS, a PPGIS method combining conventional survey elements with user-generated and register-based spatial data (Brown and Kyttä 2014). The SoftGIS method enables the joined analysis of respondent-based survey data with location-based data on the respondents' behaviors, evaluations, and environmental perceptions. To date, the SoftGIS methodology has been used in several studies with travel behavioral outcomes (Broberg et al. 2013; Haybatollahi et al. 2015; Czepkiewicz et al. 2018).

The data were collected with an online survey targeted at young adults aged 25 to 40 living in the Helsinki metropolitan area (comprising municipalities of Helsinki, Espoo, Kauniainen, and Vantaa). As the data were collected in a research project interested in urban lifestyle patterns, this age group of young, working-age adults was chosen to limit the effect of life-course variables (Czepkiewicz et al. 2018). The data collection took place in August and September 2016. A random sample of 5,000 individuals was obtained from the Finnish Population Register Center. The sample members received a letter of invitation to participate in the online survey, followed by a reminder letter. Overall, 962 individuals participated in the survey. Respondents with missing data on the attitudinal variables and those who had not marked their dwelling location were removed from the analysis, resulting in a final sample of 772 respondents and a response rate of 15.8%.

The demographic and socio-economic characteristics of the survey respondents were compared to census data available for the Helsinki metropolitan area (OSF 2018a, 2018b). The survey participants were 57% female compared to 50% of the same age group in the area. Participants with higher education (undergraduate to postgraduate degrees) were over-represented, comprising 75% of the participants compared to 46% of the Helsinki metropolitan area inhabitants in the same age group. A bias towards groups with higher levels of formal education has been reported in several PPGIS studies (Brown et al. 2017).

3.2 Measures

3.2.1 Walking outcomes

Respondents were instructed to map their primary dwelling location in the map view of the online survey. In the following mapping task, respondents were advised to locate 5 to 15 non-work destinations within the Helsinki metropolitan area that they visit frequently as a part of their daily life. For each marked location, the respondents indicated the type of the destination, the approximate frequency of visits and the most common means of transportation used to reach the destination. Destination types

included several options for utilitarian (e.g. services and running errands, grocery shopping, daycare), and recreational destinations (e.g. socializing and going out, cultural events, sports and active recreation). In order to focus on the impact of the residential environment on walking behavior, only locations that were accessed from or on the way to home were included in the analysis. On average, each respondent marked 5.6 such destinations. Distances between each destination and the dwelling were measured as street-network distance. An estimated number of monthly visits to each mapped destination was calculated based on the indicated visiting frequency. Distances to the destinations and the number of monthly visits were multiplied in order to produce estimates of the monthly travel distances. As the number of mapped destinations varied greatly between respondents, the monthly estimates were used only as ratios between the number of walking trips and the total trip count and between the walking distance and the total travel distance.

3.2.2 Neighborhood boundaries

This study applies a *home range* neighborhood boundary measure developed specifically for the use of environmental health research by Hasanzadeh et al. (2017). Here, individual neighborhood boundaries are formed as a customized minimum convex polygon modelled around locations the respondents visit frequently as a part of their daily life (Figure 1, for a detailed overview see Hasanzadeh et al. 2017). Neighborhood boundaries based on this model will be from here onwards referred to as home ranges.

The home range model was customized to fit the sample and focus of this study by redefining the maximum distance between the dwelling and destination points included in the formation of the home range. Following the criteria defined by Hasanzadeh et al. (2017), Jenk's optimization method was applied to all locations with walking as the primary travel mode. The resulting cut distance of 1.750 meters contained 39.0% of all locations and 81.8% of locations with walking as the primary travel mode and was adopted for this study. This distance is close to the 1.500-m buffer distance suggested by Grasser et al. (2017) as a suitable limit for a walkable neighborhood area in the European context.

Fig. 1. Formation of home range boundaries. D1: Minimum distance from dwelling location (500 m). D2: Minimum distance from frequently destinations (140 m). D3: Cut distance for destinations points included in the home range model (1.750 m). Source: Hasanzadeh et al. (2017).

3.2.3 Observed walkability

Compared to leisure walking, walking for transport has been found to show more consistent associations with built environment measures (McCormack and Shiell 2011). Reviews on the connection between built environment measures and walking for transport report consistent positive associations with residential density, proximity of non-residential destination, and connectivity, while associations with diverse entropy scores are less consistent (Ewing and Cervero 2010; Grasser et al. 2013; Saelens and Handy 2008). Limited results from longitudinal studies have likewise identified associations with walking for transport and residential density, land-use mix, and connectivity (Knuiman et al. 2014). In this study, the objective walkability of the residential environment was defined with a walkability index following Frank et al. (2010). The following measures were included:

- *Intersection density* as the ratio between the number of intersections within the home range and the area of the home range. Non-walkable streets such as highways and motorways were not included in the analysis
- *Residential density* as the ratio of the residential floor area and the land area with residential land-use within the home range
- *Commercial density* as the ratio of commercial and office floor area combined and the land area with commercial land-use within the home range
- *Land-use mix*, indicating diversity within the home range's land-use, was calculated following Frank et al. (2004). Four land-use types were considered: Residential, commercial, recreational

(greenspace, exercise and recreational areas) and traffic. The produced entropy score ranges from 0 to 1, with 0 equating homogeneous and 1 heterogeneous land-use.

The walkability index was calculated as the sum of the z-scores of these measures as proposed by Frank et al. (2010) [(2 x z-intersection density) + (z-net residential density) + (z-commercial floor area ratio) + (z-land-use mix)]. Based on the walkability index value, the respondents were divided into tertiles with the first tertile signifying the lowest and the third the highest observed walkability group. The index values ranged from -11.31 to 9.56, with first tertile at -1.57 and the second tertile at 1.35.

3.2.4 Walkability preference groups

Individual preference towards the level of walkability of the residential environment was evaluated with twelve attitudinal items measured on a five-point Likert-scale ranging from (1) “strongly disagree” to (5) “strongly agree” (Table 1). The respondents indicated their agreement with statements representing attitudes towards travel behavior and the residential environment with previously reported associations with walking outcomes (Frank et al. 2015; Haybatollahi et al. 2015; Schwanen and Mokhtarian 2004).

A principal axis factor (PAF) analysis using direct Oblimin rotation with Kaiser normalization was conducted on the attitudinal items in order to confirm an underlying structure and to form factors for subsequent analyses. An oblique rotation was chosen, as correlations between factors were assumed (Field 2013). Only variables with factor loadings exceeding .32 were retrieved as suggested by Tabachnick and Fidell (2013). PAF revealed four components with eigenvalues greater than 1.0 and which explained altogether 59.1% of the total variance (Table 1). Factor scores using the regression method were formed for each respondent based on their loadings on the extracted factors.

The reliability and internal consistency of the retained factors were evaluated with Cronbach’s alpha, which varied between .57 and .60 on individual factors. The overall Kaiser-Meyer-Olkin measure of the four-factor solution was .74, with individual measures all greater than .60. Bartlett’s test of sphericity was significant ($\chi^2_{(66)} = 1658.29, p < .001$), indicating that the data are suitable for the analysis. Based on the highest-scoring items, the factors were named *Residential density* (F1), *Tranquility and access to recreational areas* (F2), *Closeness to shops and services* (F3), and *Car dependency* (F4).

Table 1

Rotated factor loadings in the retained four-factor solution.

Items	Factors			
	F1	F2	F3	F4
1 I can be comfortable living in close proximity to my neighbors	.631			
2 I like living in a neighborhood where there is a lot going on	.523			
3 I am comfortable riding with strangers	.440			
4 Living in a multiple family unit would not give me enough privacy	-.375			
5 I want to live close to vast nature and recreational areas		.734		
6 I appreciate tranquillity and calmness in a residential area		.550		
7 I like to have a large yard at my home		.355		
8 Having shops and services within walking distance of my home is important to me			.691	
9 I don't mind travelling a bit longer for the services I use			-.613	
10 I appreciate good travel connections by car				.718
11 I don't mind getting around using public transportation				-.492
12 For short distances, I prefer getting around in an active way such as walking or cycling				-.447
Eigenvalue	3.06	1.68	1.29	1.06
% of variance	25.51	14.00	10.71	8.85
α	.57	.58	.60	.60

Note: Extraction method: Principal axis factoring. Rotation method: Oblimin with Kaiser normalization.

In order to identify respondents with similar attitudes towards high-walkable residential environments, a series of hierarchical and non-hierarchical cluster analyses were performed on the regression factor scores of the four attitudinal factors. As the suitable number of clusters was unknown, the clustering was performed as a two-part procedure. First, a hierarchical clustering with Ward's method and squared Euclidean distance was conducted in order to define the suitable number of clusters and to pick the initial cluster centers. Assessment of the agglomeration schedule of the hierarchical clustering supported a three-cluster solution, and a final non-hierarchical (K-means) clustering was performed to define cluster membership for each respondent. In the final solution, Cluster 1 consists of 182, Cluster 2 of 310 and Cluster 3 of 280 respondents. Factor scores of the final cluster centers (Table 2) show how these clusters differ distinctly on their walkability-related preferences.

On average, respondents belonging to Cluster 1 preferred residential areas with low density and were the most willing to travel further to reach services. They were also highly car-dependent compared to respondents in the other two clusters. On the contrary, Cluster 3 members showed a high preference for residential density and for close-by services, were the least car-dependent and did not express interest towards residential environments offering tranquillity and access to sizeable recreational areas. Respondents belonging to Cluster 2, however, had no strong preferences concerning residential density, distance to services nor the transport mode, but stood apart from the other clusters by placing greater importance on neighborhood tranquillity and access to vast recreational areas. Based on these profiles, Cluster 1 was interpreted to show a preference for low-walkable and Cluster 3 for high-walkable residential environments, whereas Cluster 2 members had no strong preference concerning the walkability of the residential environment.

Table 2

Final cluster centers of the K-means clustering.

	Factor	Cluster 1	Cluster 2	Cluster 3
F1	Density	-0.905	0.063	0.518
F2	Tranquility and access to recreational areas	0.014	0.582	-0.654
F3	Closeness to shops and services	-0.692	-0.114	0.576
F4	Car dependency	1.027	-0.041	-0.622

Note: Factor scores calculated with the regression method have a mean of 0 and a variance equal to the squared multiple correlation between the estimated factor scores and the true factor values.

3.2.5 Dissonance groups

A certain level of agreement existed between the respondent's attitudes towards walkable residential environments and the observed walkability of their residential environments. From respondents preferring low-walkable residential environments 49.5% had home ranges belonging to the lowest, 29.7% to the middle and 20.9% to the highest walkability tertile, while 51.1% of respondents preferring high-walkable environments had home ranges in the highest, 31.1% in the middle, and 17.9% in the lowest walkability tertile. Respondents without a strong walkability preference were more evenly distributed, as 37.7% of the respondents belonged to the lowest, 37.7% to the middle, and 24.5% to the highest walkability tertile. Based on these measures, four main groups indicating the presence and nature of walkability-related residential dissonance were identified (modified from Schwanen and Mokhtarian 2005b):

- *High-walkability consonants*: respondents preferring high-walkable residential environments and having a high-walkable home range
- *High-walkability dissonants*: respondents preferring low-walkable residential environments and having a high-walkable home range
- *Low-walkability dissonants*: respondents preferring high-walkable residential environments and having a low-walkable home range
- *Low-walkability consonants*: respondents preferring low-walkable residential environments and having a low-walkable home range

3.3 Statistical analyses

The statistical analyses were conducted in three parts. First, differences between the group means of demographic and socio-economic variables within the walkability preference clusters and the observed walkability tertiles were assessed with Chi-square and Kruskal-Wallis H tests. Second, Kruskal-Wallis H tests followed by pairwise comparisons were performed to analyze differences in walking estimate mean ranks between the dissonance groups.

Third, associations between the dissonance groups and selected walking outcomes were studied with ordinal logistic regression analyses. Outcome variables were formed by classifying variables on the share of walking trips and the share of walking distance into four ordered categories with equal amount of respondents. These quartiles were used as the ordered outcome measures of the regression models. Separate models were constructed for walking to recreational and to utilitarian destinations. All regression models were adjusted for demographic and socio-economic characteristics, and the fit of multiple models was compared using the Bayesian Information Criterion (BIC). Data analyses were performed with IBM SPSS Statistics v25.

4. Results

4.1 Personal and home range characteristics

Table 3 presents the respondents' socio-economic and demographic characteristics stratified by their preference towards low or high –walkable residential environments and the observed walkability of their home range. The three walkability preference clusters differed significantly on all variables but age and household-level income, and the walkability tertiles by all variables but gender and the employment status.

A visual inspection of the spatial distribution of the respondents' home ranges indicated a concentration towards the Helsinki city center and a few secondary urban nodes in the Helsinki metropolitan area (Figure 2). The home ranges of both respondents in the most walkable tertile and respondents preferring high-walkable residential environments were clustered in the most central areas, whereas respondents with low walkability preference and home ranges with low observed walkability showed a gradual dispersion towards the outer areas.

Table 3

Respondents' personal and home range characteristics stratified by the walkability preference and the observed walkability.

	Walkability preference ^a			Observed walkability ^b			Total
	Low	No pref.	High	Low	Middle	High	
	<i>n</i> = 182	<i>n</i> = 310	<i>n</i> = 280	<i>n</i> = 257	<i>n</i> = 258	<i>n</i> = 257	<i>N</i> = 772
Personal characteristics							
<i>Gender (%)</i>							
Female	47.3	64.8	55.0	61.9	55.0	54.5	57.1
Male	50.5	33.9	41.8	35.8	42.6	43.6	40.7
<i>Age, years (%)</i>							
25–28	29.1	22.9	29.3	20.3	30.2	30.2	26.7
29–32	25.3	21.9	23.2	21.5	25.0	23.8	23.2
33–36	20.3	28.1	26.1	25.5	21.8	28.2	25.5
37–41	25.3	27.1	21.4	32.7	23.0	17.9	24.6
<i>Highest level of education (%)</i>							
Secondary or basic education	25.8	15.5	17.9	17.9	22.5	16.0	18.8
Vocational education	11.0	6.5	3.6	9.7	7.4	2.3	6.5
Undergraduate	29.7	29.4	31.8	30.4	29.1	31.5	30.4
Graduate	30.8	42.3	42.9	37.7	35.3	46.3	39.8
Postgraduate	2.2	6.5	3.9	4.3	5.4	3.9	4.5
<i>Employment status (%)</i>							
Employed	79.7	72.6	73.2	77.8	69.8	75.9	74.5
Unemployed	3.8	6.1	5.4	4.3	7.4	4.3	5.3
Student	11.5	9.4	14.6	8.6	12.8	14.0	11.8
Other	4.9	11.9	6.8	9.3	10.1	5.8	8.4
<i>Household type (%)</i>							
Single person	28.0	26.5	38.2	20.6	32.6	40.1	31.1
Couple living together	33.0	35.5	34.3	29.6	35.3	38.5	34.5
Couple with child/children	35.7	35.5	24.6	46.7	29.5	18.7	31.6
<i>Household monthly gross income (%)</i>							
Less than 3,000 euros	23.1	30.0	36.4	21.0	34.9	36.2	30.7
3,000–6,500 euros	48.9	45.5	38.6	48.6	43.8	38.9	43.8
More than 6,500 euros	22.0	19.0	19.6	24.9	16.7	18.3	19.9
Home range characteristics							
<i>Area (km²)</i>	1.26	1.42	1.51	1.29	1.36	1.60	1.42
<i>Residential land-use (%)</i>	37.1	35.0	33.6	37.2	34.5	33.3	35.0
<i>Commercial land-use (%)</i>	11.8	14.2	17.5	7.5	14.9	22.1	14.8
<i>Land-use mix</i>	0.80	0.83	0.87	0.74	0.87	0.90	0.83
<i>Walkability index</i>	-1.65	-0.66	1.80	-4.29	-0.14	4.44	0.00

Note: Chi-square test were used for categorical variables (gender, education level, employment status, household type, and type of residence) and Kruskal–Wallis H tests for ordinal and continuous variables. Because of missing data, all percentages do not equal 100%.

^a In-group differences are significant ($p < .05$) on all variables but age and household income.

^b In-group differences are significant ($p < .05$) on all variables but gender and employment status.

Walkability preference

Observed walkability

0 5 10 15 km

□ Municipality border

— Main roads

----- Rail network

Fig. 2. Spatial distribution of the home ranges within the Helsinki metropolitan area stratified by the walkability preference and the observed walkability of the residential environment.

4.2 Walking distance and trip frequency

The observed walkability of the residential environment was associated with an increase in frequency of walking for transport and a decrease in average trip distances to all, recreational and utilitarian destinations (Table 4). Walking estimates associated with the walkability preference groups conveyed a similar pattern. The share of walking trips and the share of walking distance increased and the average

distances to all destinations decreased moving from the low-walkability to the high-walkability preference group.

Table 4

Walking estimates stratified by the walkability preference and the observed walkability of the home range (all means).

	Walkability preference			Observed walkability			Total
	Low <i>n</i> = 182	No pref. <i>n</i> = 310	High <i>n</i> = 280	Low <i>n</i> = 257	Middle <i>n</i> = 258	High <i>n</i> = 257	<i>N</i> = 772
All destinations							
Average distance to all destinations (km)	5.46	4.93	3.54	6.07	4.65	2.94	4.54
Average distance to walking destinations (km)	1.72	1.59	1.14	1.67	1.48	1.21	1.43
Share of walking trips	39.72	43.69	59.39	38.48	46.22	60.70	48.57
Share of walking distance	24.63	26.82	41.10	22.14	28.86	43.44	31.59
Recreational destinations							
Average distance to all destinations (km)	6.85	5.94	4.18	7.60	5.43	3.49	5.49
Average distance to walking destinations (km)	1.79	1.79	1.29	1.83	1.62	1.36	1.58
Share of walking trips	37.40	41.45	52.39	37.95	43.50	52.22	44.62
Share of walking distance	22.04	27.05	37.65	22.32	27.59	39.52	29.88
Utilitarian destinations							
Average distance to all destinations (km)	3.26	2.98	2.01	3.46	2.72	1.91	2.70
Average distance to walking destinations (km)	1.39	1.19	0.90	1.37	1.09	0.94	1.10
Share of walking trips	38.63	43.41	63.61	33.97	49.15	65.59	49.47
Share of walking distance	31.15	36.36	56.89	26.25	40.72	59.36	42.04

Note: In-group differences (Kruskal-Wallis H test) are significant ($p < .05$, $df = 2$, adjusted Bonferroni method) on all variables but the average distances to all, leisure, and maintenance walking destinations.

Pairwise comparisons of the shares of monthly walking distance and walking trips between the dissonance groups revealed several mean rank differences within both the groups of low and high observed walkability. (Table 5). Respondents preferring high-walkable residential environments walked a significantly greater share of their estimated travel distance to all destinations than those preferring low-walkable environments in both high and low -walkable environments. Stratified by trip purpose, certain differences were observed between walking to utilitarian and recreational destinations. The shares of both walking trips and walking distance to recreational destinations grew with higher walkability preference in high-walkable environments, while no significant in-group differences were detected in low-walkable environments.

On the contrary, the share of walking trips and share of walking distance to utilitarian destinations increased with higher walkability preference in low-walkable, but not in high-walkable residential environments.

Table 5

Kruskal-Wallis H test results and pairwise comparisons of walking estimates within dissonance groups in high and low - walkable residential environments.

	<i>n</i>	Share of walking trips			Share of walking distance		
		All	Recreational	Utilitarian	All	Recreational	Utilitarian
High-walkable							
Dissonants (C1)	38	110.06	98.05	92.49	108.43	97.87	91.22
No strong pref. (C2)	76	112.34	113.73	100.45	109.82	110.95	100.12
Consonants (C3)	143	140.04 ^c	134.37 ^b	116.64	141.08 ^{b,c}	135.9 ^{b,c}	117.19
Low-walkable							
Consonants (C1)	90	109.59	-	92.18	109.19	-	91.32
No strong pref. (C2)	117	125.88	-	114.79 ^b	125.23	-	113.73 ^b
Dissonants (C3)	50	144.00 ^b	-	125.64 ^b	146.19 ^b	-	127.10 ^b

Note: No mean ranks are reported if in-group differences are not significant at level $p < .05$. For all tests, $df = 2$.

^b Pairwise comparison to C1 statistically significant, $p < .05$ (adjusted with Bonferroni method).

^c Pairwise comparison to C2 statistically significant, $p < .05$ (adjusted with Bonferroni method).

4.3 Odds of walking by dissonance group

Associations between the ordered walking outcomes and the dissonance groups were assessed with models comparing all other dissonance groups to the reference category of high-walkability consonants (Table 6). Both models including all mapped destinations indicated significantly lower odds of walking for all dissonance groups. For the share of walking trips, the highest odds were associated with other preference groups with high-walkable home environments (OR=0.51, OR= 0.49), followed by low-walkability dissonants (OR=0.44). In both models, the lowest odds were associated with low-walkability consonants and respondents living in low-walkable residential environments but having no clear walkability preference. Low-walkability dissonants were found be likelier to walk a higher share of their estimated travel distance than high-walkability dissonants.

Looking at walking by trip purpose, all other dissonance groups had significantly lower odds of walking a high share of their estimated number of trips or travel distance to recreational destinations than high-walkability consonants. Both models found low-walkability dissonants to have higher odds than high-walkability dissonants. The models on walking to utilitarian destinations, on the other hand, showed no significant differences in the walking behaviors of high-walkability consonants and high-walkability respondents with no strong walkability preference. These results, as do the unadjusted results presented

in Table 5, suggest that individual walkability preference affects utilitarian walking less in high-walkable than in low-walkable residential environments. In addition, respondents living in low-walkable environments had lower odds of walking to utilitarian than to recreational destinations. These results indicate that the associations between observed walkability and walking behavior vary by trip purpose, and are more consistent for walking to utilitarian than to recreational destinations.

Table 6

Results of ordered logistic regression analyses on associations between the dissonance groups and walking outcomes.

	All destinations				Recreational destinations				Utilitarian destinations			
	Walking trips		Walking distance		Walking trips		Walking distance		Walking trips		Walking distance	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Gender (ref. female)												
Male	0.87	0.61–1.25	0.82	0.57–1.18	1.08	0.75–1.54	0.97	0.68–1.39	0.98	0.66–1.44	0.91	0.61–1.34
	1.00	0.96–1.04	1.01	0.97–1.05	1.02	0.98–1.07	1.02	0.98–1.07	0.96	0.92–1.01	0.97	0.93–1.02
Age (years)												
Household income (ref. < 3,000 €)												
3,000–6,500 €	1.14	0.66–1.98	0.98	0.56–1.69	1.06	0.61–1.84	0.87	0.50–1.52	0.77	0.43–1.4	0.69	0.38–1.25
> 6,500 €	1.18	0.76–1.81	1.17	0.76–1.80	0.93	0.60–1.43	0.87	0.56–1.35	1.22	0.77–1.95	1.17	0.73–1.86
Employed (ref. no)	0.59	0.38–0.93	0.53	0.33–0.82	0.71	0.45–1.11	0.74	0.47–1.16	0.77	0.48–1.25	0.76	0.47–1.23
University degree (ref. no)^a	1.29	0.86–1.95	1.55	1.02–2.34	1.29	0.85–1.96	1.54	1.01–2.34	1.05	0.67–1.63	1.10	0.71–1.72
Children in household (ref. no)	1.12	0.74–1.68	1.19	0.79–1.80	1.71	1.13–2.58	1.76	1.16–2.67	1.06	0.69–1.64	1.01	0.66–1.56
Dissonance (ref. high-walkability consonant)												
Low-walkability consonant	0.15	0.09–0.26	0.12	0.07–0.22	0.34	0.20–0.58	0.25	0.15–0.44	0.10	0.06–0.19	0.10	0.05–0.19
Low-walkability, no strong preference	0.28	0.17–0.47	0.23	0.14–0.39	0.40	0.24–0.66	0.30	0.18–0.50	0.21	0.12–0.36	0.19	0.11–0.33
Low-walkability dissonant	0.44	0.24–0.83	0.41	0.22–0.77	0.50	0.26–0.93	0.44	0.23–0.83	0.36	0.19–0.70	0.35	0.18–0.67
High-walkability dissonant	0.49	0.24–0.98	0.40	0.20–0.81	0.43	0.20–0.90	0.39	0.18–0.82	0.47	0.23–0.99	0.43	0.21–0.90
High-walkability, no strong preference	0.51	0.30–0.87	0.43	0.25–0.73	0.53	0.31–0.91	0.45	0.26–0.77	0.57	0.32–1.02	0.57	0.32–1.03
BIC^b	1188.54		1179.68		1181.54		1171.30		1056.73		1048.85	
– Log likelihood	-548.3		-543.8		-544.98		-539.86		-483.39		-479.47	
n	461		461		448		448		402		402	

All outcome measures have been classified into ordered outcome variables (1 = 1st quartile, 2 = 2nd quartile, 3 = 3rd quartile, 4 = 4th quartile). Bolded values are significant ($p < 0.05$).

^a Including undergraduate, graduate and postgraduate degrees.

^b Bayesian Information Criterion (BIC). Lower values indicate a better model fit.

5. Discussion and conclusions

The health benefits of engagement in daily active travel have been well documented (Durand et al. 2011; Saelens and Handy 2008). Empirical evidence from both cross-sectional and longitudinal studies suggests that changes in the built environment have the potential to increase walking for transport and for recreational purposes (Giles-Corti et al. 2013; Kamruzzaman et al. 2016b). Likewise, individual attitudes towards characteristics of the residential environment and different travel modes have been connected to walking behavior in various studies (Bagley and Mokhtarian 2002; Kitamura et al. 1997; Schwanen and Mokhtarian 2005b). The concept of residential dissonance (Schwanen and Mokhtarian 2004) provides a framework for observing associations between travel behavior and the varied interactions of travel and land-use preferences and the built environment. With respect to walking, this means observing the effect of individual preferences on walking behavior in urban environments with varied support for transport or leisure. This study has argued that as the environmental measures associated with different active travel modes and purposes differ to some extent (Saelens and Handy 2008; McCormack and Shiell 2011; Sugiyama et al. 2012), residential dissonance studies focusing on these behaviors should aim for a higher conformity between the applied residential preference, the observed built environment attributes and the dependent variables. This study has aimed to meet some of these preconditions by developing a framework specific for outcomes measuring walking behavior, as the applied neighborhood boundaries, residential preferences and the observed built environment were operationalized with measures related to walking for transport. A principal axis factor analysis followed by a cluster analysis was applied to identify respondent groups with distinct residential preferences.

The effect of walkability-related residential dissonance on walking outcomes was studied in the context of non-work transport trips in the Helsinki metropolitan area. Significant associations were found between walking for transport, residential location, and preference for residential environments supportive of walking. Comparing the estimated shares of monthly walking distance, respondents living in the areas with the highest observed walkability walked all in all more than those living in low-walkable areas, whereas respondents preferring high-walkable neighborhoods walked more than those preferring low-walkable neighborhoods. These results are generally in line with observations from earlier dissonance studies with no differentiation between active travel modes (Badland et al. 2012; Kamruzzaman et al. 2013, 2016a; Schwanen and Mokhtarian 2005b). Results of the ordinal logistic regression analyses confirmed that low-walkability consonants had the lowest and high-walkability consonants the highest adjusted odds of walking a high share of their estimated number of monthly trips and travel distance. Positive associations were found between walking for transport and the level of objectively measured walkability, supporting similar results reported in several studies accounting for neighborhood preference (Owen et al. 2007; McCormack et al. 2012; Frank et al. 2015). Separate analyses were conducted by destination type, and indicated that preference for high-walkable

environments had a greater effect on walking to recreational than on walking to utilitarian destinations. While respondents living in and preferring low-walkable residential environments had the lowest odds of walking to recreational destinations, respondents living in low-walkable environments but preferring high-walkable ones were likelier to walk than those living in high-walkable but preferring low-walkable environments. Results on walking to utilitarian destinations were more consistently associated with the observed walkability of the respondent's residential environment. Nevertheless, high individual preference for walkable residential environments increased the likelihood of walking to utilitarian destinations also in the low-walkable areas.

Prior research on the relationships between residential dissonance and walking for transport remains limited. The results of this study share similarities with those presented by Frank et al. (2007) and De Vos et al. (2012), who found preference for walkable residential environments to affect walking behavior more than the built environment. However, whereas Frank et al. concluded that inhabitants preferring low-walkable environments walked little regardless of the neighborhood type, built environment was found to affect the walking behavior of also these respondents in the Helsinki metropolitan area sample. Likewise, the results differ to some extent from those presented by Cho and Rodríguez (2014), who observed no difference between dissonant and consonant suburban residents in terms of their utilitarian and recreational walking. They concluded that dissonant suburban residents had fewer possibilities for realizing their opposing mobility preferences than urban dissonants and were thus likely to travel by private vehicle regardless of a positive attitude towards walking. Similar conclusions were reached by Schwanen and Mokhtarian (2005b) who, when observing the travel patterns of urban and suburban respondents in the San Francisco Bay area, noticed that residential dissonance was reflected more in the behavior of urban than suburban residents.

Some disparities in these results are likely caused by contextual differences between the study areas, as some differences in the relationships between the built environment and walking for transport in European and North American or Australian context have been reported (Van Holle et al. 2012). A recent study from the Helsinki metropolitan area shows that during the day-time, walking and public transportation provide faster access to grocery stores than do private vehicles for approximately 60% of the area's population (Tenkanen et al. 2016). Thus, the geographical disparities in the availability of close-by services and transport mode options are not as pronounced as in more car-oriented urban environments. Moreover, the operationalization of the dissonance measures is bound to reflect on the achieved results. This study applied a local activity space model by Hasanzadeh et al. (2017) defining individual neighborhood boundaries for each respondent based on their residential location and frequently visited everyday destinations. Like all ego-centered neighborhood boundaries, the applied model prioritizes the observed characteristics of the local residential environment over the dwelling's relative location within the urban area. This trade-off shifts the focus to the individual and to individual

environmental exposure within the residential environment, which might result in differences compared to studies applying fixed spatial units.

As demonstrated by the results of this research, residential dissonance provides a conceptual framework for analyzing the ways individual travel and land-use –related attitudes impact walking in diverse spatial settings. This multi-level approach connects the concept of residential dissonance to the ecological model of health behavior (Sallis et al. 2006; Sallis and Owen 2015) emphasizing the multiple levels of influence on individual behavior. Overall, the results presented here support the existing evidence on the interconnectedness of both intrapersonal and built environment characteristics in facilitating walking behavior. This notion further supports the argument presented for example by Giles-Corti (2006) and recently by Kamruzzaman et al. (2016b) in favor of targeting both “people” and “places” while planning interventions aimed at increasing walking for transport. Translated into policy, this implies that policies could benefit both from the inclusion of interventions targeting specific populations as well as those targeting material features of the built environment. Detailed knowledge on the interactions between these two may provide valuable assistance in designing effective interventions.

This study has certain limitations. First, the outcome variables do not include comparable measurements of actual accumulated travel distances, as the data reflects the respondents’ self-reported frequently visited destinations and not the entirety of their daily travel behavior. Second, due to the cross-sectional nature of the data, possible temporal variations in the presence of residential dissonance could not be detected. Residential dissonance may occur for limited periods, as households anticipate upcoming changes in residential preferences and self-select themselves to residential environments expected to accommodate them in the future. Moreover, this study did not account for the kind of possible attitudinal changes that existing longitudinal research has identified to be slow, but observable amongst dissonant residents (Kamruzzaman 2015). Finally, due to a relatively low sample size, this study did not proceed to analyze the socio-economic and demographic characteristics of the identified dissonance groups. However, a more nuanced understanding of the determinants of residential dissonance could help to identify subpopulations that could potentially derive the greatest benefit from interventions aimed at increasing the use of active transportation modes. Findings from other studies indicate that while high-walkable residential environments may increase the total level of physical activity across diverse socio-economic and demographic subpopulations, certain health-related groups might be more likely to benefit from population-level interventions (Forsyth et al. 2009; McCormack et al. 2014).

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