

TRANSPORT FINDINGS

Constraints or Freedom? Relationships between Destination Accessibility and Activity Spaces

Julia Duro, MUP^{1,2}, Jae Hyun Kim, DDes², Carole Voulgaris, PhD², Dawon Oh, DDes²¹ Department of Sociology, Universidad de Granada, ² Department of Urban Planning and Design, Harvard University

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Findings

The area of an individual's daily activity space may be constrained by difficulties traveling long distances or by proximity advantages in dense areas that reduce the need to travel far from home. Using travel diary data from 327 individuals in Granada, Spain for both a weekday and a weekend, this study examines the relationship between activity space areas and destination accessibility by car and non-car modes. We find that lower accessibility is associated with smaller activity spaces on weekdays, while weekend activity space areas are better explained by household resources. We interpret these patterns using a constraints-versus-freedom lens.

1. Questions

Activity spaces represent areas within which individuals routinely travel (Cagney et al. 2020). The normative interpretation of variation in activity space areas depends on the narrative used to explain it. In a constraints-based narrative, larger spaces indicate greater opportunities to travel widely. In a freedom-based narrative, smaller spaces reflect less need for extensive travel. We examine the relationship between destination accessibility of individuals' homes and activity space size. If small activity spaces are associated with lower accessibility or more constrained resources, this supports a constraints-based view. If smaller activity spaces correspond with higher accessibility, this supports a freedom-based view.

2. Methods

This study draws on data collected between May and June 2023 in the city of Granada, Spain (Duro et al. 2025). The survey employed a multi-stage sampling design structured across three levels: district, census tract, and demographic quotas within each tract. Individuals were approached in public spaces according to predefined gender and age quotas for their census tract. Participants recalled all trips made on the most recent weekday and one day of the most recent weekend, including trip purpose, transport mode, and destination. All reported locations were geolocated. Respondents provided informed consent, in accordance with the University of Granada's Code of Ethics, permitting the anonymous use of their data.

For this study, an individual's activity space was defined as a minimum convex polygon (MCP) representing the geographic footprint of daily routines. Following Hasanzadeh, Broberg, and Kyttä (2017), home locations were buffered by 500 m to represent the immediate neighborhood environment, a widely used metric in activity-space research (Hasanzadeh, Broberg, and Kyttä 2017; Larsen et al. 2009; Markevych et al. 2016; Wendel-Vos et al. 2004; Wolch et al. 2011). Other stops were buffered by 140 m, an empirically derived threshold averaging kernel density and nearest-neighbor measures between trips (Hasanzadeh, Broberg, and Kyttä 2017) to capture spatial uncertainty. [Figure 1](#) illustrates the steps taken to construct these activity spaces. We excluded one individual's weekday activity space and three individuals' weekend spaces that exceeded eight standard deviations above the mean. In the remaining sample, all activity space areas were within four standard deviations of the mean.

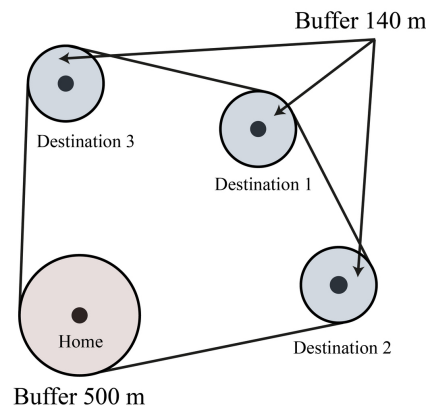


Figure 1. Illustration of the construction of an individual's activity space based on Hasanzadeh, Broberg, and Kyttä (2017)

We calculated accessibility using parcel-level land-use data for Granada province, from the Spanish Land Use Information System (SIOSE) of the National Geographic Institute (Instituto Geográfico Nacional 2023). Parcel land uses were grouped into four categories:

- leisure (retail, restaurants, tertiary sector, indoor culture and recreation),
- other services (financial and public services such as schools and hospitals),
- outdoor recreation (sports facilities and parks), and
- residential.

Agricultural and industrial land uses were excluded from the analysis.

Land-use intensity was defined:

- as total land area for outdoor recreation,
- as population for residential uses (estimated in Equation 1), and
- as gross floor area for leisure and other services.

$$P_{parcel} = P_{tract} \left(\frac{GFA_{parcel}}{GFA_{tract}} \right) \quad (1)$$

where P_{parcel} = estimated population of the parcel,

P_{tract} = population of the census tract, from the Annual Population Census (INE 2023)¹,

GFA_{parcel} = total gross floor area of all residential buildings on the parcel, and

GFA_{tract} = total gross floor area of all residential buildings in the tract.

We used the *r5r* package (Pereira et al. 2021) to compute eight accessibility metrics for each respondent's home: accessibility by car and accessibility by a combination of walking and transit for each of four destination types. Gravity-based accessibility was calculated as the sum of parcel sizes in Granada province, weighted by travel time using a logistic decay function Equation 2.

$$A_{d,m} = \sum_p \frac{I_p}{1 + e^{\pi\sqrt{3}(T_{p,m}-30)/15}} \quad (2)$$

where $A_{d,m}$ = the accessibility to destination type, d , by mode, m ,

I_p = the *land use intensity* (as defined above for each destination type) of parcel p , and

T_p = the travel time in minutes from the respondent's home to parcel p by mode, m .

The above decay function produces a median of 30 minutes and a standard deviation of five minutes. The median of 30 minutes approximates a reasonable travel time for routine daily trips, and the standard deviation of five minutes to allow for a less rigid cutoff at 30 minutes than would be achieved through a lower value (which would more closely approximate the step function that characterizes a cumulative-opportunity measure of accessibility). Santana Palacios and El-Geneidy (2022) have found that

¹ INE (2023). *Censo Anual de Población*. https://www.ine.es/dyngs/INEbase/operacion.htm?c=Estadistica_C&cid=1254736176992&menu=ultiDatos&cidp=1254735572981

gravity-based and cumulative-opportunity measures of accessibility tend to be highly correlated and analysis conclusions are unlikely to be sensitive to the choice of decay function. We tested our analysis with alternative decay functions that vary the median value by ± 10 and find that the resulting accessibility scores are highly correlated ($r \geq 0.90$).

Accessibility scores were standardized (centered and scaled to a mean of zero and a standard deviation of one), as shown in Equation 3.

$$A'_{d,m} = \frac{A_{d,m} - \mu_{A_{d,m}}}{\sigma_{A_{d,m}}} \quad (3)$$

where $A'_{d,m}$ = the standardized accessibility to destination type, t , by mode, m ,

$\mu_{A_{d,m}}$ = the mean of $A_{d,m}$ within the sample of study respondents' residences,

$\sigma_{A_{d,m}}$ = the standard deviation of $A_{d,m}$ within the sample of study respondents' residences.

Correlations among the four standardized car access metrics were greater than 0.94, as were correlations among the four standardized walk/transit access metrics. These highly correlated measures that had been standardized were averaged to form combined indicators of access by car and by walking/transit, as shown in Equation 4.

$$A_m = \frac{A'_{l,m} + A'_{s,m} + A'_{o,m} + A'_{r,m}}{4} \quad (4)$$

where A_m = accessibility by mode, m ,

$A'_{l,m}$ = standardized accessibility to leisure destinations by mode, m ;

$A'_{s,m}$ = standardized accessibility to other service destinations by mode, m ;

$A'_{o,m}$ = standardized accessibility to outdoor recreation destinations by mode, m ;

$A'_{r,m}$ = standardized accessibility to residential destinations by mode, m .

[Figure 2](#) illustrates the spatial distribution of respondents' homes and their accessibility measures. Note that these normalized values of access are not comparable across modes. [Figure 2](#) shows that access without a car varies more than access by car.

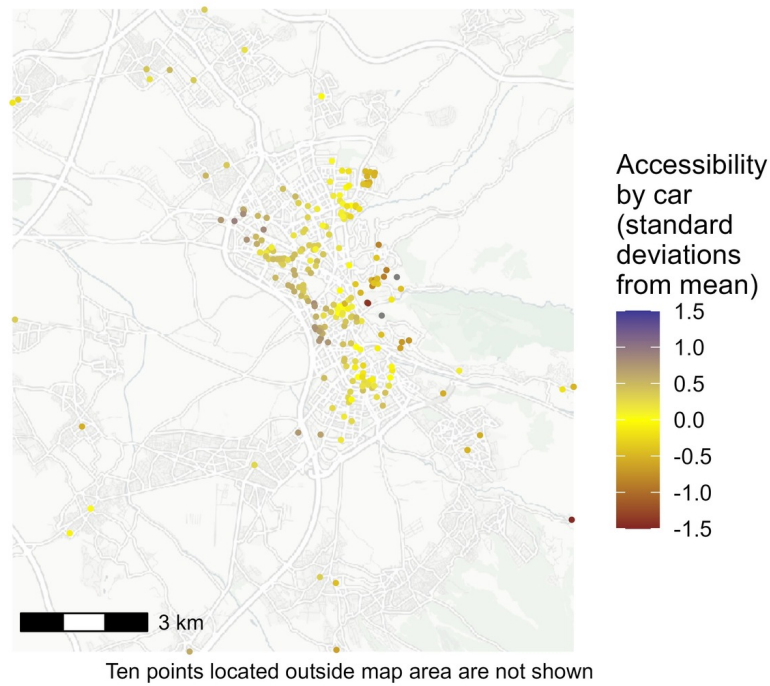


Figure 2. Spatial distribution of survey respondents' residences and associated accessibility by car (Base map source: CARTO, OpenStreetMap contributors)

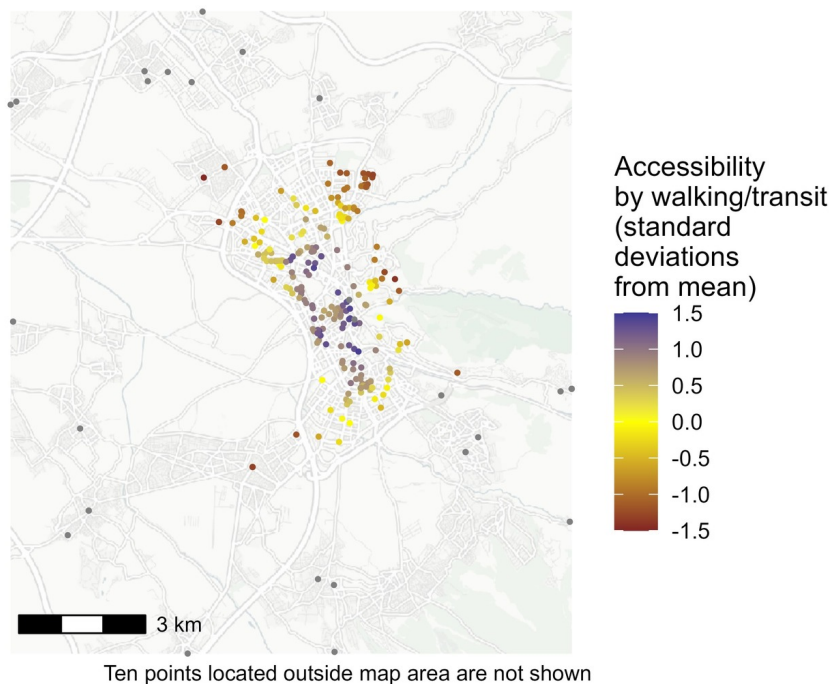


Figure 3. Spatial distribution of survey respondents' residences and associated accessibility by walking/transit (Base map source: CARTO, OpenStreetMap contributors)

We estimated a regression model predicting the log-transformed activity space area for weekdays and weekends. [Table 1](#) lists variables with descriptive statistics and the number of observations excluded due to outliers or missingness. The final sample comprised 327 individuals.

Variable name	Description	Mean or proportion	Standard deviation	Effect on sample (number of observations removed due to missingness or outliers)
Outcome variables				
Weekday activity space	Area (km ²) of convex hull around home and destination buffers (log transformed in models)	8.4	26.6	1
Weekend activity space		17.3	51.1	3
Predictor variables				
No vehicles	In zero-vehicle household	28%	-	12
Access by car	Standard deviations from the mean for access by car from home	0.00	0.99	
Access by walking/transit	Standard deviations from mean for transit/walk access from home	0.00	0.99	
Work status				2
Not in labor force	Not in a category below	27%	-	
Student	Attends school	13%	-	
Unemployed	Seeking work	11%	-	
Part-time	Employed part time	11%	-	
Full-time	Full time or self-employed	37%	-	
Age	Age in years	48.4	19.0	
Female	Identifies as female	53%	-	
Lives with children	Lives with children	31%	-	
Lives with spouse/partner	Lives with spouse/partner	46%	-	
Lives with parent(s)	Lives with own parent(s)	13%	-	
Household Income (Euros per month)				35
Low income	Less than 1,100	24%	-	
Low middle	Between 1,100 and 1,800	26%	-	
Middle income	Between 1,801 and 2,700	28%	-	
High middle income	Between 2,701 and 3,900	14%	-	
High income	Greater than 3,900	8%	-	

Table 1. Variables included in regression analyses.

3. Findings

A model estimated with all variables in [Table 1](#) showed multicollinearity, with a VIF value of 6.39 for Work Status. When this variable was removed from the model, remaining predictors had VIF values less than two for both models. [Table 2](#) summarizes the final model results.

	Weekday activity-space area (log-transformed)			Weekend activity space area (log-transformed)		
	R ² = 0.18			R ² = 0.12		
	Estimate	Standard Error	p-value	Estimate	Standard Error	p-value
Intercept	1.64	0.24	< 0.001	2.66	0.32	< 0.001
No vehicles	-0.40	0.17	0.016	-0.53	0.23	0.023
Access by car	-0.09	0.07	0.194	-0.01	0.10	0.932
Access by walking/transit	-0.29	0.08	< 0.001	-0.11	0.11	0.293
Access by car : no vehicles	0.27	0.27	0.330	0.09	0.37	0.816
Access by walking/transit : no vehicles	0.16	0.17	0.340	0.15	0.23	0.522
Age	-0.01	0.00	0.011	-0.02	0.00	0.002
Female	-0.23	0.13	0.070	0.17	0.18	0.338
Lives with children	0.13	0.15	0.415	-0.55	0.21	0.010
Lives with spouse/partner	0.07	0.16	0.678	-0.02	0.22	0.911
Lives with parent(s)	-0.41	0.22	0.058	-0.71	0.30	0.019
<i>Household income (relative to middle income)</i>						
Low income	-0.34	0.19	0.072	-0.84	0.26	0.001
Low middle income	-0.23	0.17	0.181	-0.48	0.24	0.042
High middle income	0.08	0.21	0.707	-0.64	0.29	0.026
High income	0.22	0.25	0.384	-0.78	0.35	0.026
Note: Bold text indicates 95% confidence, gray text indicates less than 90% confidence.						

Table 2. Results of regression models

On weekdays, older individuals and those living with parents have smaller activity spaces. Controlling for these and other predictors, greater accessibility by walking/transit is associated with smaller activity spaces, consistent with the freedom-based narrative.

Accessibility is not a significant predictor of weekend activity spaces, which are better explained by household resources, supporting a constraint-based narrative. Individuals in households with children or without a vehicle have smaller weekend activity spaces. Interestingly, middle-income individuals have the largest weekend spaces relative to other income groups. The difference between low- and middle-income categories supports a constraints-based view, while the difference between middle- and high-income categories supports a freedom-based one. Middle-income households may enjoy greater freedom for discretionary trips while facing fewer time constraints than high-income peers (Tao et al. 2020).

These findings support a freedom-based narrative for weekday activity spaces and a constraints-based narrative for weekend spaces.

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