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How far do people walk and cycle for different activities? Evidence from the Netherlands

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1. Introduction

Travelling is more and more associated to severe environmental problems, particularly when motorised transport modes are involved. People mostly travel because they perform (daily life) activities that are situated at different locations. One way to ensure mobility and, hence, activity participation while reducing travel-related problems such as air pollution or congestions is to achieve a considerable modal shift towards active modes (i.e. walking and cycling). However, this requires first and foremost spatial planning in which activity locations are available at proximity so that they can be reached by bike or on foot (e.g. Alfonzo, 2005; Heinen et al., 2010). While this level of accessibility is already conceptualised in theories such as smart growth or the compact city (Daniels, 2001; Dieleman & Wegener, 2003), little is known about how far people actually walk and cycle to perform their daily activities. The Netherlands offer an interesting case to study trip distances travelled on foot and by bike with their high shares of active modes (Schaap et al., 2015) and their long tradition of space efficient spatial planning (Wagenaar, 2015).

From a planning perspective, it is particularly relevant to know how observed trip distances are related to frequent daily life activities. Reichnam (1976) proposed a hierarchy scheme that groups activities which are assumed to share similar levels of priority in daily schedules with regard to their significance for daily life (Akar et al., 2011):

- Subsistence activities: work, education.
- Maintenance activities: shopping, services (e.g. visit a doctor).
- Leisure activities: social & recreational activities (e.g. visit friends).

The increasing hierarchy (bottom to top) of these three groups might also influence trip distances. Subsistence activities potentially entail longer distances as they are mandatory and the location is often determined. Contrarily, activities that have a more discretionary character such as maintenance and leisure activities are expected to be shorter since they are typically more flexible in timing and location choice. However, these considerations are embedded in a context where people are expected to choose available motorised transport modes when a personal threshold value in distance or, similarly, in travel time is exceeded. As a consequence, it is uncertain if differences in active mode trip distances can be found between trips that are associated to different trip purposes.

For this reason, we aim to investigate active mode trip distances and potential differences between different trip purposes for both walking and cycling trips. This knowledge will help spatial planners to assess walking and cycling accessibility at the most essential level, namely the distance-wise acceptance. In the remainder of the abstract, we describe the data used in the analysis, outline the applied statistical procedures and give an overview of the outcomes, before providing some concluding comments and an overview of the full paper.

2. Data: the Dutch Mobility Panel

The research is based on the data of the Dutch Mobility Panel from 2014. The Dutch Mobility panel includes a series of different surveys conducted repeatedly with the same participants and has been described in more detail elsewhere (Hoogendoorn-Lanser et al., 2015). For this analysis on trip distances, the data from a 3-day travel diary was merged with two surveys on personal and household characteristics of the participant. The resulting data pool allows to link reported travel distances to a rich set of trip features (such as trip purposes) and to personal and household attributes. The data cleaning and filtering included the removal of uncomplete surveys, unrealistic values and trips with an origin or destination outside of the Netherlands. Only trips were considered whose main mode was the bicycle or walking and for which one of the trip purposes work, services, education, shopping, visit or leisure were reported. The filtering resulted in 12,372 trips (3,437 walking and 8,935 cycling trips), originating from 2,432 different persons that live in 1,577 households.

3. Methodology: Analysis plan

In order to investigate differences in travel distances between trip purposes, trips were first assigned to the categories cycling and walking. In each category, trips were grouped according to their trip purpose (work, services, education, shopping, visit and leisure). Subsequently, these groups were compared with each other, using primarily the *IBM SPSS statistics 24* software package. The analysis contained several steps. First, some descriptive statistics were calculated for each mode. These include the distribution of trips between the different trip purposes, the median distances of each group as a measure of central tendency and interquartile ranges (IQR) to display the dispersion. Next, differences in trip distances between trip purposes of each travel mode were statistically assessed by means of a Kruskal-Wallis test. This test was chosen due to heteroscedasticity in the data. It investigates if there are statistically significant differences between the trip distance distributions of all trip purpose groups. To identify the causes of these overall differences, the trip distance distribution of each trip purpose group was compared to all other groups by means of in total 15 Mann-Whitney U tests. In order to control for an inflated Type 1 error rate (i.e. an incorrectly assumed difference between trip distance distributions) that is typically related to multiple comparisons, simple Bonferroni corrections were applied, dividing the .05 level of significance by the number of tests ($\alpha \leq .003$). Finally, effect sizes for the Mann-Whitney U tests were calculated as described by Field (2009, p.550) and presented as absolute values to assess the magnitude of the encountered differences.

4. Results

Table 1 presents the distribution of trips, the medians and the IQRs between the considered trip purposes for both active modes.

Table 1. Descriptive statistics of trip distances

	Walking				Cycling				All modes
Trip purpose	**N**	**%**	**Median[1]**	**IQR[1]**	**N**	**%**	**Median[1]**	**IQR[1]**	**%**
Work	249	7.2	0.45	0.80	1747	19.6	3.00	3.50	21.5
Services	171	5.0	0.50	0.70	465	5.2	1.50	2.00	5.4
Shopping	1435	41.8	0.50	0.60	2430	27.2	1.30	1.70	26.6
Education	108	3.1	0.50	0.80	1369	15.3	4.00	5.00	8.6
Visit	538	15.7	0.40	0.60	816	9.1	2.00	2.50	13.8
Leisure	936	27.2	0.50	0.75	2108	23.6	2.00	2.30	24.1
All trips	**3437**	**100.0**	**0.50**	**0.70**	**8935**	**100.0**	**2.00**	**3.00**	**100.0**

[1] Reported in kilometres

Walking is mostly related to shopping, leisure and visit trips which together account for almost 85% of all reported walking trips. While the percentages of these trip purposes are higher than in the overall distribution of trips over trip purposes, the shares of work and education trips lie below it. This indicates that the corresponding activity locations are often beyond walking distances. With respect to the median and the interquartile range, only small deviations can be found between walking trip distances for different trip purposes. Consequently, trip purpose does not seem to affect how far people are willing to walk and people rather switch to another travel mode when distances get longer.

Cycling trips, on the contrary, are more equally distributed among the different trip purposes. The distribution follows essentially the distribution of trips of all modes indicating that activity locations are often found within travel distances which people are willing to cycle. In comparison to walking trips, differences of the medians and IQR are more pronounced. It seems that particularly trip purposes with fixed activity locations (education, work) are substantially longer than the overall median and interquartile range, while trip purposes with flexible locations (shopping, services and leisure) are shorter.

The statistical assessment of the differences by means of two Kruskal-Wallis tests indicates that the trip distances differ significantly between the trip purposes for both walking ($H (6) = 72.923$, $\rho < .05$) and cycling ($H (6) = 1282.007$, $\rho < .05$). Tables 2 and 3 present the results of the 15 conducted pairwise comparisons for both active modes. Table 2 indicates which Mann-Whitney U tests revealed statistical significance (see Annex 1 for the precise values) and Table 3 shows the corresponding effect sizes.

Table 2. Significant Mann-Whitney U tests at a .003 level of significance

Test	**Work**	**Services**	**Shopping**	**Education**	**Visit**	**Leisure**
Work		N.S.	N.S.	N.S.	S.S.	N.S.
Services	S.S.		S.S.	N.S.	S.S.	N.S.
Shopping	S.S.	S.S.		N.S.	S.S.	S.S.
Education	S.S.	S.S.	S.S.		N.S.	N.S.
Visit	S.S.	S.S.	S.S.	S.S.		S.S.
Leisure	S.S.	S.S.	S.S.	S.S.	N.S.	

Walking →

N.S. = non-significant, S.S. = significant

← Cycling

Table 3. Effect sizes

Effect sizes	Work	Services	Shopping	Education	Visit	Leisure
Work		0.10	0.02	0.00	0.12	0.07
Services	0.29		0.09	0.11	0.19	0.01
Shopping	0.38	0.06		0.02	0.09	0.11
Education	0.18	0.40	0.49		0.10	0.05
Visit	0.20	0.09	0.15	0.36		0.19
Leisure	0.20	0.10	0.21	0.36	0.02	

Walking →

← Cycling

No effect	Small effect	Medium effect	Large effect
< |0.10|	< |0.25|	< |0.50|	≥ |0.50|

The results of Table 2 suggest that particularly walking distances for trip purposes visit (4 out of 5) and shopping (3 out of 5) are most often significantly different from other trip purposes. When having a look at the effect sizes, visit (having a slightly lower median) is most different from other trip purposes; however the effect sizes are still small.

The results regarding cycling trip distances are quite different. Besides the comparison between visit and leisure, all Mann-Whitney U tests indicate statistically significant differences. With respect to the effect sizes, 6 comparisons reveal small (light grey) and 6 even show medium (dark grey) effect sizes. The striking trip purpose is education, which is substantially different from all other trip purposes. In total, 4 tests in relation to education have a medium effect (shopping, services, visit, leisure). This means that cycling for education involves significantly longer distances than for other purposes. A further medium effect is observed between work trips and shopping trips. In essence, the results confirm statistically the key figures presented in Table 1 where education and shopping represented the most different trip purposes in terms of medians and IQR of cycling trip distances.

5. Conclusions

The analysis showed that walking trip distances are relatively stable between trip purposes, while cycling trip distances vary substantially. Regarding the latter, differences particularly occur between trip purposes associated to spatially determined activity locations (education, work) and trip purposes where there is generally more spatial freedom of choice (shopping, services). These findings highlight a preference for shorter cycling distances. However, people are apparently willing to travel longer distances when the activity is of high importance in the schedule, even by bicycle. This effect seems to be even more pronounced when constraints concerning the mode choice set can be assumed, as for example for pupils who travel to school. From a planning perspective, the high frequency of (grocery) shopping shows that particularly this trip purpose can be systematically planned in favour of the active modes. Contrary to other activities, origins and destinations of this frequently performed activity are known to planners and land-use schemes can systematically be developed in order to reduce travel distances to the next supermarket.

While travel distances are usually integrated in mode choice models as an important influence factor, this research provides us with some explicit signals of how far people actually travel actively and how travel distances differ for different trip purposes. This helps to assess accessibility by the active modes on the most essential level. For instance, it can be evaluated if travel distances to school allow active mode use. However, it is noteworthy that the findings only display observed behaviour concealing maximal thresholds of distances people are willing to cycle or walk and unobserved trips due to too long trip distances.

In the full paper, the analysis on active mode trip distances will be extended and also investigates the influence of socio-economic and spatial characteristics of the trip maker on active mode trip distances.

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Annexes

Annex 1. Test numbers of the Mann-Whitney U tests

Test	**Work**	**Services**	**Shopping**	**Education**	**Visit**	**Leisure**
Work		**1**	**2**	**4**	**7**	**11**
Services	**1**		**3**	**5**	**8**	**12**
Shopping	**2**	**3**		**6**	**9**	**13**
Education	**4**	**5**	**6**		**10**	**14**
Visit	**7**	**8**	**9**	**10**		**15**
Leisure	**11**	**12**	**13**	**14**	**15**	

Walking →

← Cycling

Annex 2. Results of the Mann-Whitney U tests

	Walking				**Cycling**			
Tests	**N**	**U**	**ρ**	**Z**	**N**	**U**	**ρ**	**Z**
1	420	18738.0	0.036	-2.097	1747	256449.0	**0.000**	-12.247
2	1684	172660.5	0.395	-0.850	4177	1191033.5	**0.000**	-24.277
3	1606	102939.5	**0.001**	-3.460	2895	508708.0	**0.001**	-3.418
4	357	13436.0	0.991	-0.011	3116	943389.5	**0.000**	-10.137
5	279	8036.0	0.065	-1.842	1834	147781.5	**0.000**	-17.296
6	1543	74683.0	0.528	-0.631	3799	685492.0	**0.000**	-30.179
7	787	57165.0	**0.001**	-3.320	2563	533963.5	**0.000**	-10.258
8	709	34033.5	**0.000**	-5.150	1281	168453.5	**0.001**	-3.347
9	1973	340302.5	**0.000**	-4.071	3246	794314.0	**0.000**	-8.536
10	646	24632.0	0.012	-2.507	2185	317869.5	**0.000**	-16.888
11	1185	105760.5	0.024	-2.251	3855	1406224.0	**0.000**	-12.669
12	1107	78714.5	0.732	-0.343	2573	417078.5	**0.000**	-5.048
13	2371	582207.5	**0.000**	-5.504	4538	1947826.0	**0.000**	-13.973
14	1044	45519.0	0.089	-1.700	3477	826815.5	**0.000**	-21.332
15	1474	193383.0	**0.000**	-7.446	2924	835251.0	0.225	-1.215

In bold: Tests with a level of significance of $\alpha \leq .003$