Stability and innovation of human activity spaces

Stefan Schönfelder *

IVT - Institute for Transport Planning and Systems
ETH - Swiss Federal Institute of Technology Zurich

January 2005

* with thanks to KW Axhausen
Intra-personal level of mobility

Behavioural variability

Inter-personal level

Single day

Person X

Intra-personal level

Person 1
Person 2
Person 3
Person 4
Person 5

Mean

e.g. sum of travel time

Mo Tu We Th Fr Sa

Time

Person 1
Person 2
Person 3
Person 4
Person 5

Mean
Long-term issues in travel behaviour

Temporal phenomena: Behavioural issues over time

• Stability
• Regularity / Rhythms
• Variability
• Dynamics

Spatially:

How may locational choice and the intensity of individual usage of urban space be visualised and measured?

(Geocoding/GPS facilitate)
## Data sources

<table>
<thead>
<tr>
<th>Place</th>
<th>Duration</th>
<th>Mode</th>
<th>Mode Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Travel diaries:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uppsala 1971</td>
<td>5 weeks</td>
<td>All</td>
<td></td>
</tr>
<tr>
<td>Mobidrive 1999 (Karlsruhe, Halle)</td>
<td>6 weeks</td>
<td>All</td>
<td></td>
</tr>
<tr>
<td>Zürich 2001 (Leisure only)</td>
<td>12 weeks</td>
<td>All</td>
<td></td>
</tr>
<tr>
<td>Thurgau (CH) 2003</td>
<td>6 weeks</td>
<td>All</td>
<td></td>
</tr>
<tr>
<td><strong>GPS – studies:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Borlänge 2000-2002</td>
<td>up to 80 weeks</td>
<td>car</td>
<td>(240,000 trips)</td>
</tr>
<tr>
<td>Copenhagen AKTA 2001-2003</td>
<td>24 weeks</td>
<td>car</td>
<td></td>
</tr>
<tr>
<td>Commute Atlanta 2004</td>
<td>&gt; 52 weeks</td>
<td>car</td>
<td></td>
</tr>
</tbody>
</table>
Activity space: Concept

(Micro-geographical) Indicator for individual space use

Geometrical (two-dimensional) form based on distribution of visited activity locations over time ➔ OBSERVED behaviour

Individual panel data allows physical mapping / listing / enumeration of visited locations and travel demand in-between

Several conceptual studies with focus on travel potentials (e.g. space-time prisms)

But: Few empirical work due to missing data
Assumed relationship between activity space and costs

- Size of activity space
- (Generalised) Travel costs

Increasing costs
Decreasing costs

Hysteresis because of investment in social capital and mental maps
Issues

- Size of activity spaces
- Number of places visited
- Structure of activity spaces
- Innovation in destination choice
Measuring the size of activity spaces: Problems

Transformation of information about the places of contact

- Social relationships
- Origin/Destination
- Sale or usage

in a low-dimensional measure of

- Comparison over time (for one traveller)
- Comparison between travellers
Example: Visited places over 6 weeks (local)

Woman, 24
Fulltime work, single
216 trips in 6 weeks
Example: Commuters to Zürich (2000)
Approaches

„Parametric“:

• 95% confidence ellipse

„Non-(semi)-parametric“:

• Spatial smoothing (kernel – density estimates)
• Network of shortest trips
• Network of monitored trips
Approach 1: 95% confidence ellipse

Concept:
Probability

Smallest possible area of a true value of the population (i.e. activity locations)

Measure: Area

Shows dispersion / concentration

Axhausen, Botte und Schönfelder, 2004
Example: Zürich commuters (2000)
Number of trips in 6 weeks

Mobidrive:
- All trips of respondents
- Car trips of “car users”

Borlänge GPS:
- Car trips of “car users”

Schönfelder und Axhausen, 2004
Mobidrive: 95% confidence ellipses

* Local trips only
### Variance of activity spaces over time

<table>
<thead>
<tr>
<th>Correlation coefficient</th>
<th>Last period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trips</td>
</tr>
<tr>
<td><strong>This period</strong></td>
<td></td>
</tr>
<tr>
<td>Trips</td>
<td></td>
</tr>
<tr>
<td>Borlänge</td>
<td>0.71</td>
</tr>
<tr>
<td>Copenhagen</td>
<td>0.66</td>
</tr>
<tr>
<td>Places</td>
<td></td>
</tr>
<tr>
<td>Borlänge</td>
<td></td>
</tr>
<tr>
<td>Copenhagen</td>
<td></td>
</tr>
<tr>
<td>95% CE</td>
<td></td>
</tr>
<tr>
<td>Borlänge</td>
<td></td>
</tr>
<tr>
<td>Copenhagen</td>
<td></td>
</tr>
<tr>
<td><strong>N periods</strong></td>
<td></td>
</tr>
<tr>
<td>Borlänge</td>
<td>849</td>
</tr>
<tr>
<td>Copenhagen</td>
<td>252</td>
</tr>
</tbody>
</table>

Sichfelder und Axhausen, 2004
Number of unique locations

“Unique location” is defined as a combination of

- Address (street address, zip code, municipality code etc.)
- Activity purpose

Systematic problem of GPS – data:

- How to “summarise” varying parking positions to a single location?
Number of places as function of number of trips (Thurgau 2003)

Schönfelder und Axhausen, 2004
### Number of places as a function of number of trips

<table>
<thead>
<tr>
<th>Location</th>
<th>Slope</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobidrive</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>All</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td>Car drivers</td>
<td>0.22</td>
</tr>
<tr>
<td>Thurgau</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>All</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>Car drivers</td>
<td>0.25</td>
</tr>
<tr>
<td>Uppsala</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>All</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>Car drivers</td>
<td>0.25</td>
</tr>
<tr>
<td>Copenhagen</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Car drivers</td>
<td>0.28</td>
</tr>
<tr>
<td>Borlänge</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Car drivers</td>
<td>0.13</td>
</tr>
</tbody>
</table>
Strukture of activity spaces

Criteria:

- Share of trips to most visited locations
- Cluster
Share of most important destinations of all trips (Mobidrive)

Schönfelder und Axhausen, 2004
Distribution of activity clusters – number (All trips)

Cluster: 1 km radius; minimum 3 unique locations and 10% of all trips

Schönfelder und Axhausen, 2004
Distribution of activity clusters – number (car drivers)

Cluster: 1 km radius; 3 unique locations and 10% of all car trips
<table>
<thead>
<tr>
<th>Purpose</th>
<th>Mobi All</th>
<th>Mobi Fulltime</th>
<th>Thurgau All</th>
<th>Thurgau Fulltime</th>
<th>Uppsala All</th>
<th>Uppsala Fulltime</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home</td>
<td>55</td>
<td>57</td>
<td>43</td>
<td>42</td>
<td>44</td>
<td>44</td>
</tr>
<tr>
<td>Leisure</td>
<td>12</td>
<td>11</td>
<td>14</td>
<td>10</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Work</td>
<td>11</td>
<td>24</td>
<td>15</td>
<td>22</td>
<td>18</td>
<td>25</td>
</tr>
<tr>
<td>School</td>
<td>8</td>
<td>1</td>
<td>8</td>
<td>11</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Grocery</td>
<td>6</td>
<td>4</td>
<td>9</td>
<td>5</td>
<td>19</td>
<td>12</td>
</tr>
<tr>
<td>Private business</td>
<td>5</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Long-term shopping</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Pick/Drop</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Work related</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
Innovation in destination choice

Two types of observation:

- “New” locations over the reporting / monitoring period
- Locations visited for the first time
“New” locations

- Borlänge; car trips, all purposes
- Copenhagen; car trips, all purposes
- Uppsala; all purposes
- Thurgau; all purposes
- Mobidrive; all purposes
- 12 week leisure study; leisure only

Number of new locations/day [n]

Week of reporting period

Schönfelder und Axhausen, 2004
Places visited for the first time (Thurgau 2003)

First time or never before less than 4 visits
Often: 4 to 10 visits

Schönfelder und Axhausen, 2004
Summary

- Activity spaces are measurable
- The relationship between number of trips and number of unique locations seems constant
- AS has a structure with few clusters
- The set of known places increases permanently
- The “rate of innovation” is constant
- The size of activity spaces is temporarily not or only partly stable
Appendix: Measuring activity spaces (Part 2)
Approach 2: Kernel densities

Density surface created by distribution of locations weighted by frequency of visit

Measure: Area with positive density value

Focus: Clustering
Example: Zürich’s commuter shed 2000
Approach 3: Shortest path network

Smallest geometry based on all O-D-relations observed (e.g. shortest paths)

Measure: Length of geometry / area spanned / buffered area

Focus: Spread of locations
Obvious refinements

All:
  • Segmentation by type of interaction; time period
  • Appropriate weighting schemes (ln ?)

Confidence ellipse, Kernel densities:
  • Removal of a-priori excluded spaces

Shortest path networks:
  • Use mode-specific networks
  • Use stochastic assignment
Refinement: Exclusion of excluded areas
Additional information

Confidence ellipse:
  • Angle of the main axis relative to reference point
  • Mean vector between point of interaction and base

Kernel densities:
  • Number of contiguous areas (clusters)

Shortest path networks:
  • All descriptive statistics for network graphs
  • Flow estimates
Additional information: Flow estimates


