Activity space: Concept, measurement and first results

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Introduction

Principle question

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

Outline

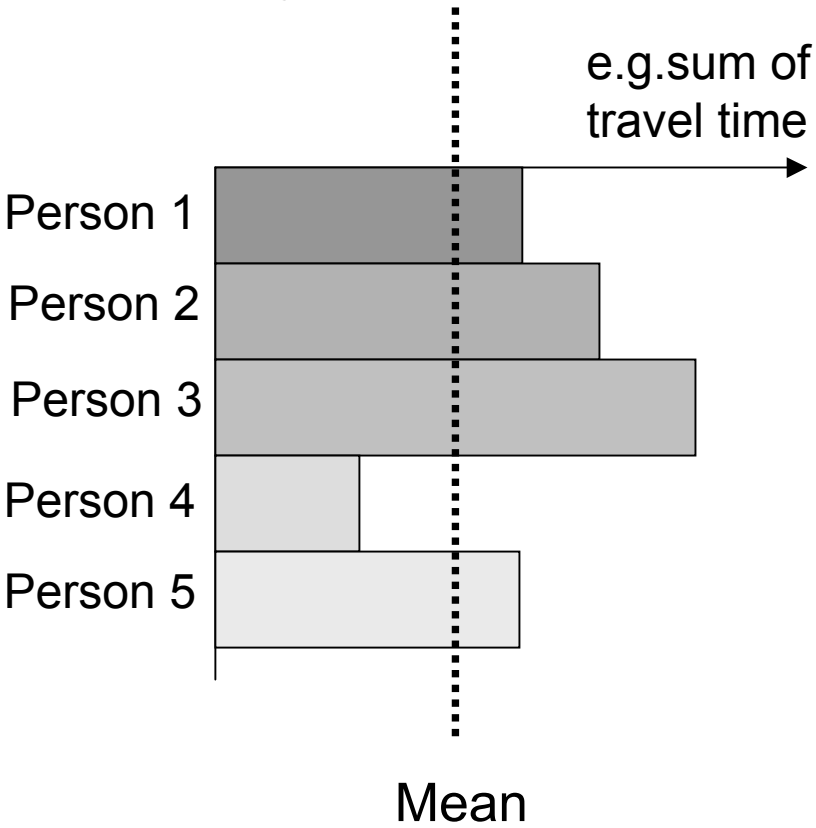
- Variability in travel behaviour and recent data collection
- Spatial mobility: Questions and hypotheses
- The activity space concept
  - Concept
  - Measurement
  - Results
- The Borlänge GPS data - Outlook on further work

Intra-personal level of mobility

Behavioural variability

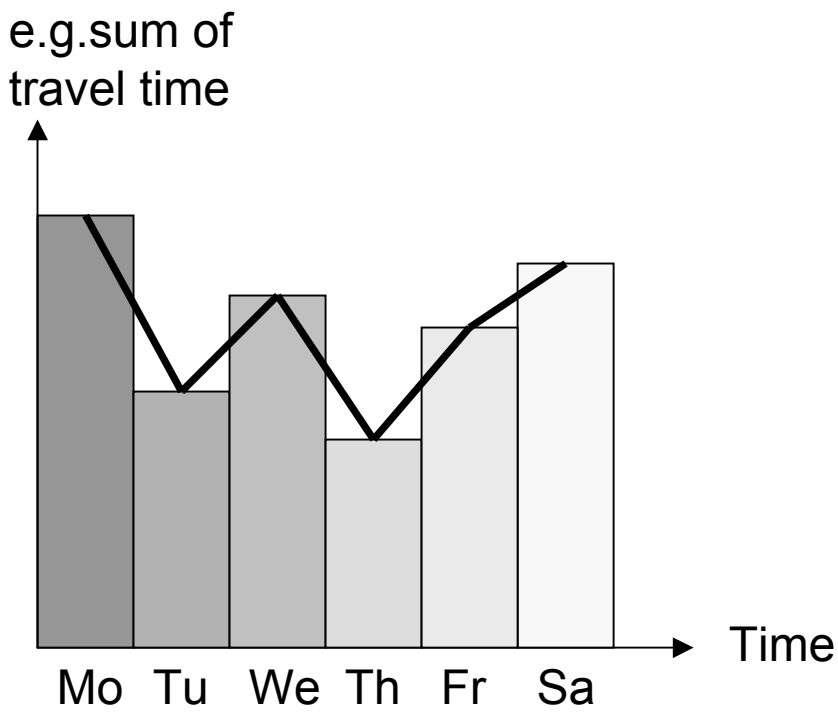
Inter-personal level

Single day



Intra-personal level

Person X



Long-term issues in travel behaviour: Mobi*drive* survey

Temporal phenomena: Behavioural issues over time

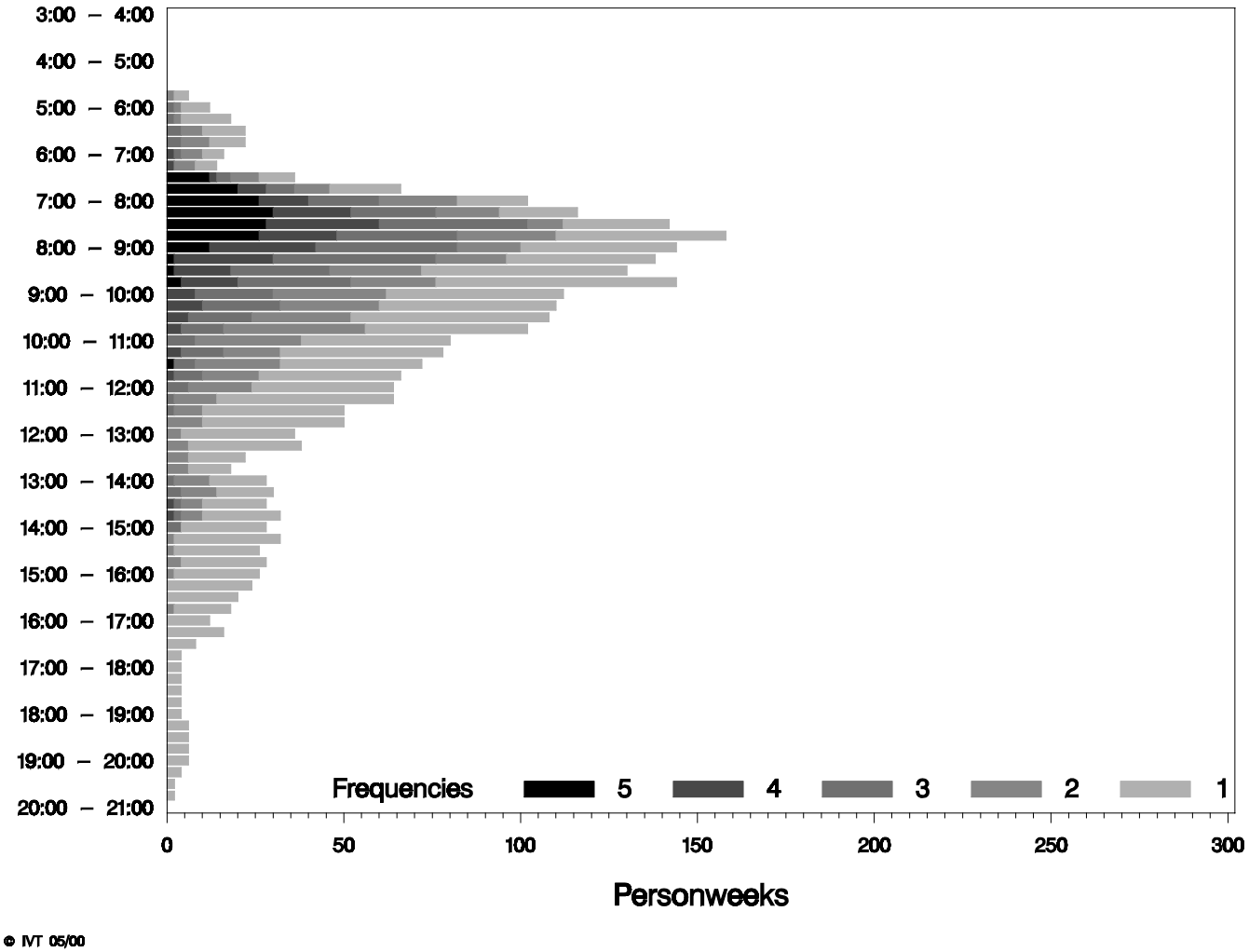
- Stability
- Regularity / Rhythms
- Variability
- Dynamics

New suitable data? - Mobi*drive* 1999

- 6-week travel diary
- Ordinary PAPI design
- German cities Karlsruhe und Halle
- 162 households / 361 persons / 52.000 trips

Geocoding of destination addresses (local trips: exact, regional trips: coarse)

Analysis example: Stability in departure time choice*



* First trips from home, self-employed respondents, interval: 30 minutes

Spatial aspects of mobility: Questions and hypotheses

- Distribution of visited locations in space
- Organisation of activity patterns based on distribution (activity chaining)
- Feedback between spatial opportunities and realised locational choice
- Methodological: Adequate representation of locational choice and measurement of space use

- Equivalent observations to temporal issues: Large degree of routinised behaviour in locational choice
- Travel and activity demand around and between the pegs of daily life (home, work place)
- Necessities, time budgets, travel potentials (e.g. mobility tools) and spatial perception / knowledge determine behaviour

Activity space: Concept (1)

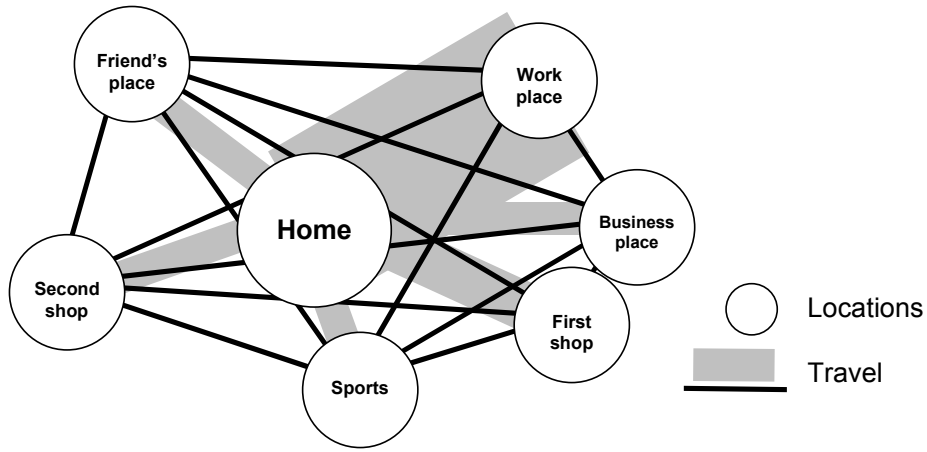
(Micro-geographical) Indicator for individual space use

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)

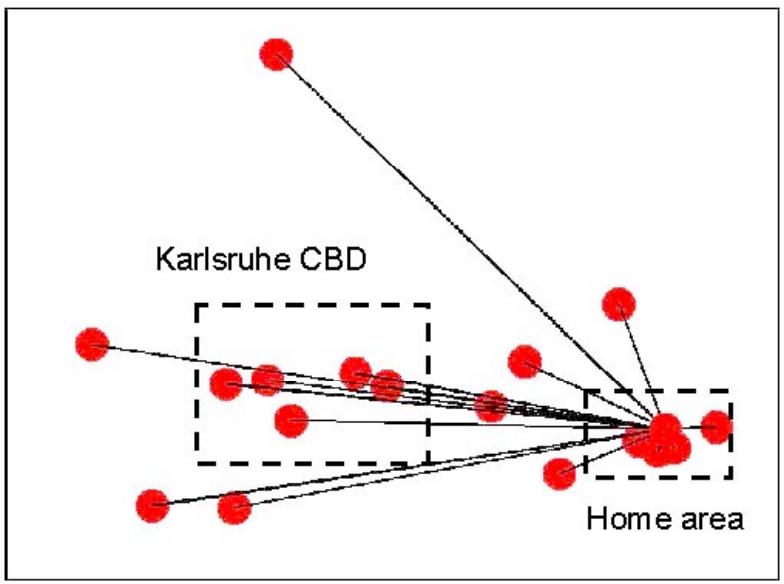
But: Few empirical work due to missing data

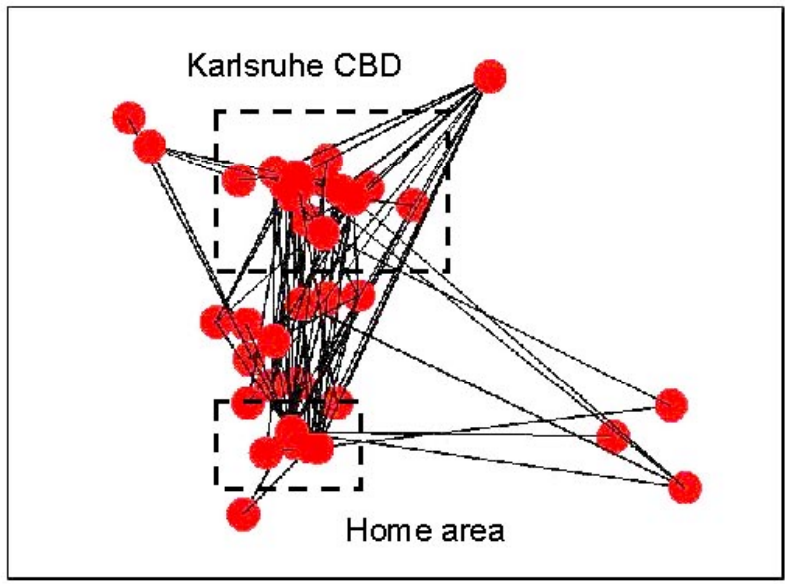


Activity space: Concept (2)

Objectives (summary)

- verification of hypotheses on individual activity spaces
- help to improve forecasts on locational choice
- reveal interaction between spatial supply and realised demand





Activity space: Measurement approaches (concepts)

Geometrical forms show...

- Probability

  Given an observed locational choice, which further locations are likely?

- Density / intensity

  Which urban space is used intensively according to one's needs and preferences?

- Perception / memorising

  When moving through nets, which adjacent area is perceived and possibly memorised?

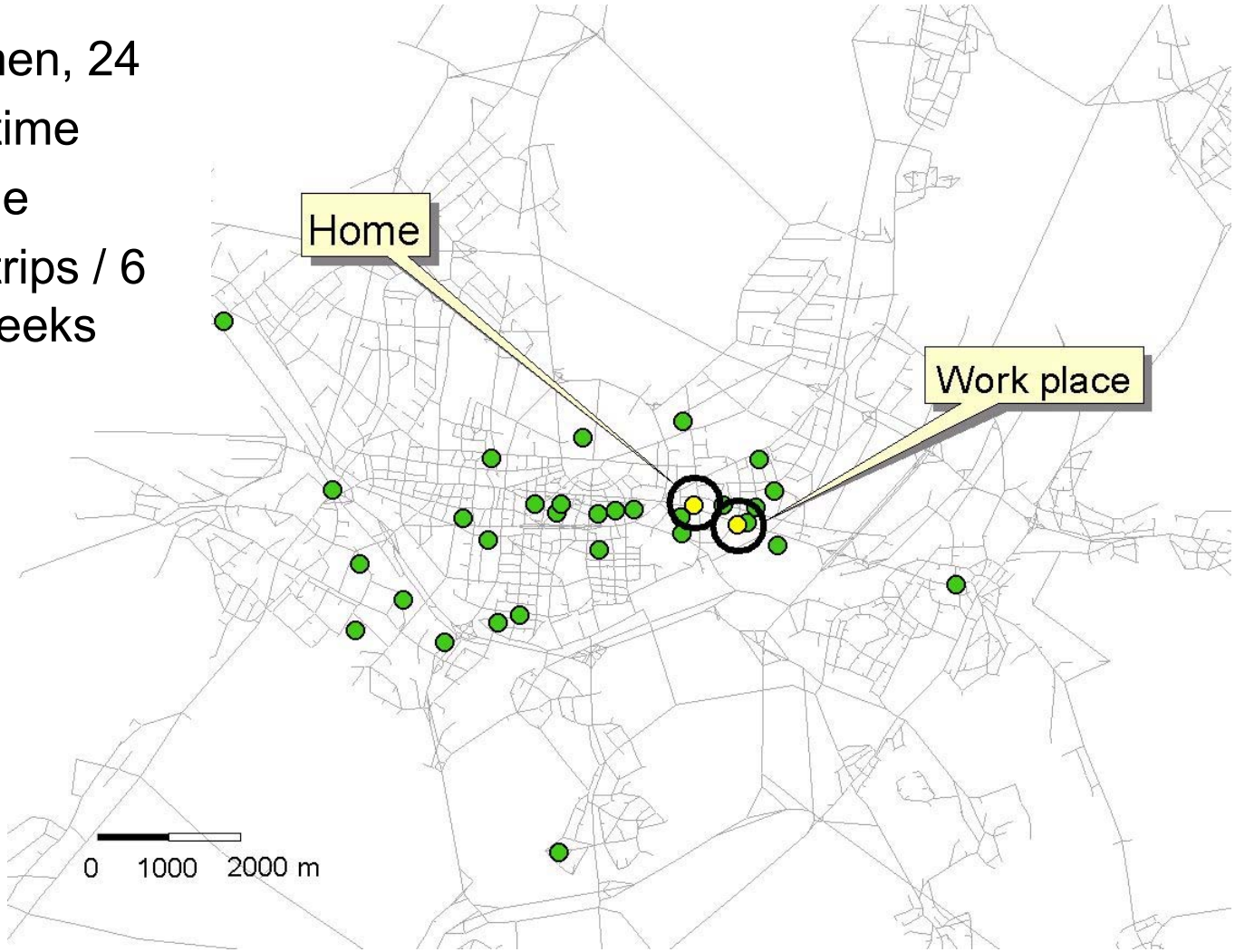
Activity location distribution: Example (1)

Women, 24

Full-time

Single

216 trips / 6 weeks



Activity location distribution: Example (2)

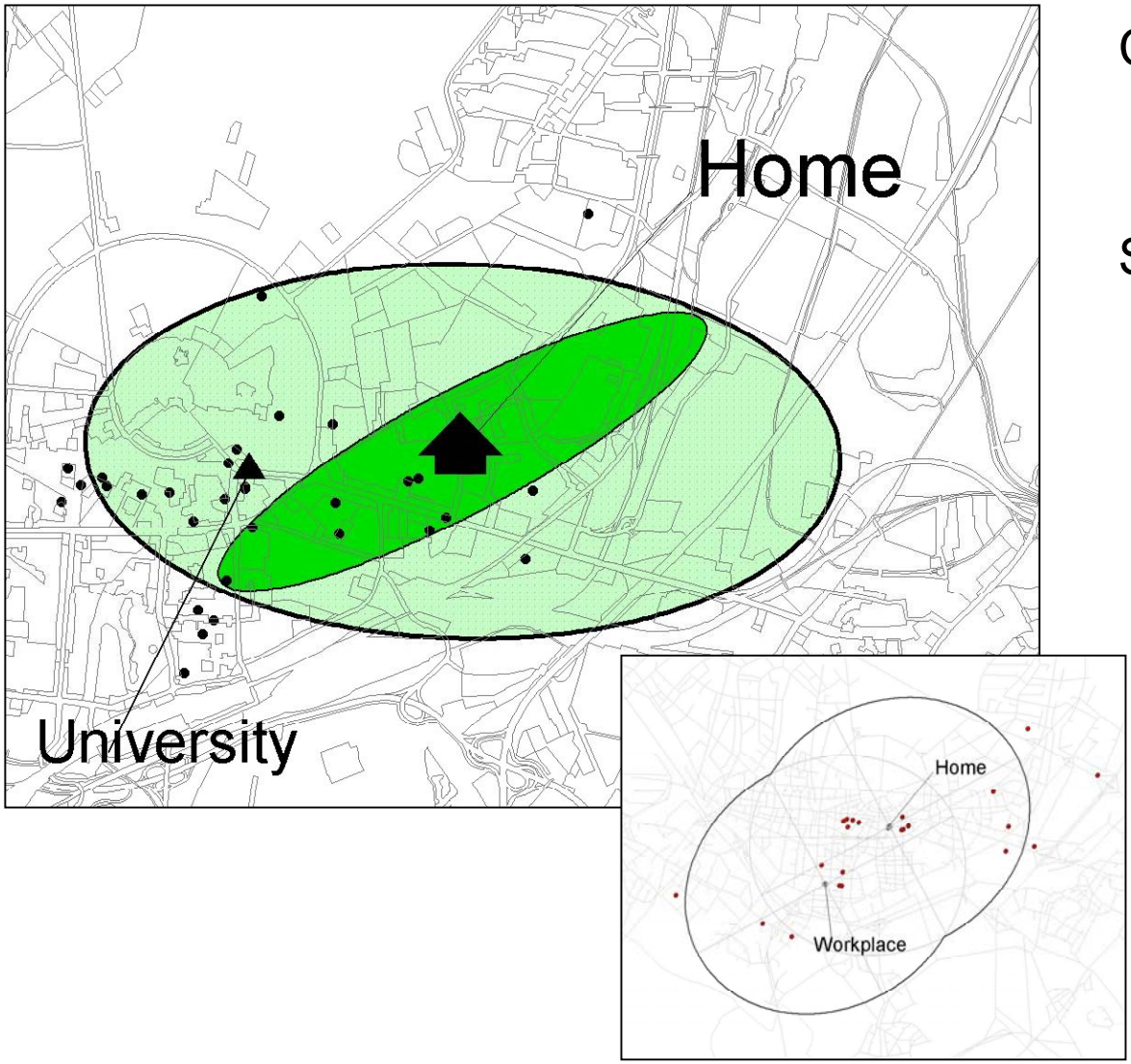
Man, 50

Full-time

1 child

120 trips / 6 weeks

Measurement approaches (1): Confidence ellipse



Concept:
Probability

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

Measure: Area

Shows dispersion / concentration

Measurement approaches (2): Kernel densities

0	2	3	2
0	7	0.9	0
1	0.1	6	1

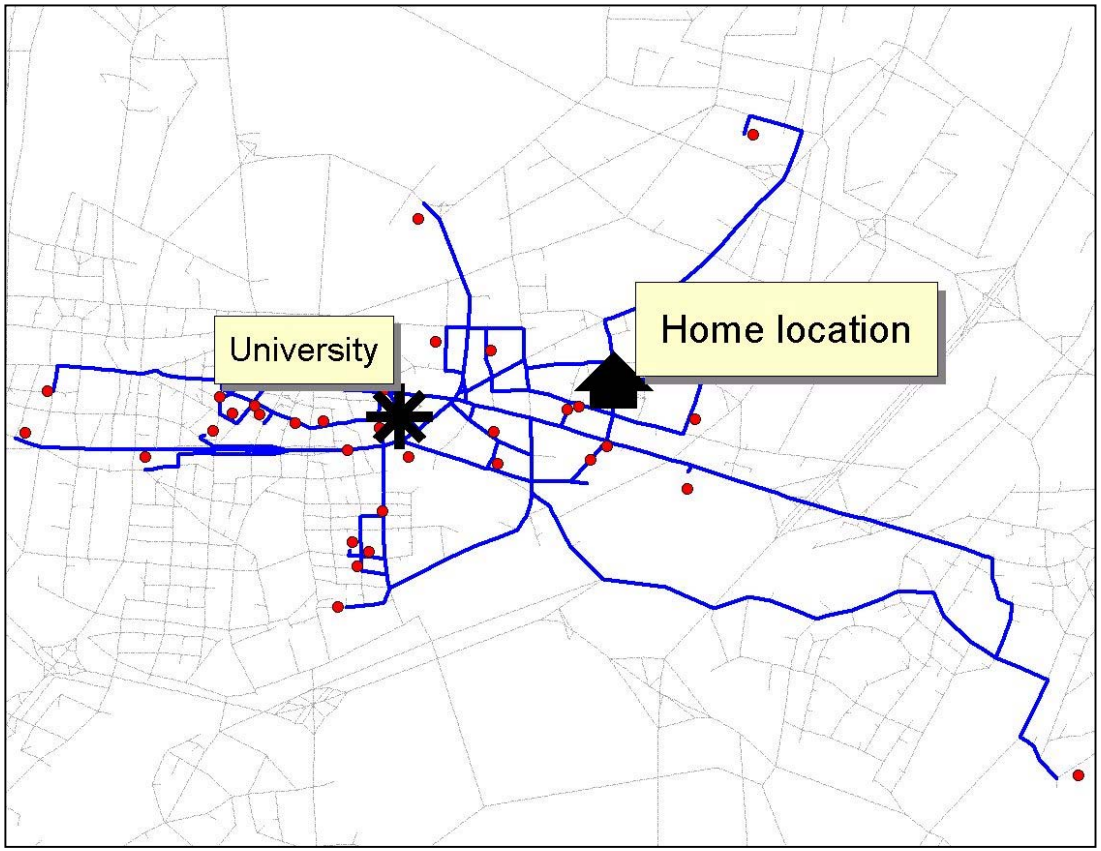
Concept: Density of usage

Density surface created by distribution of locations (optional: frequency of visit)

Measure: Area with positive density value or “volume”

Shows clusters, sub-centres

Measurement approaches (3): Minimum spanning tree



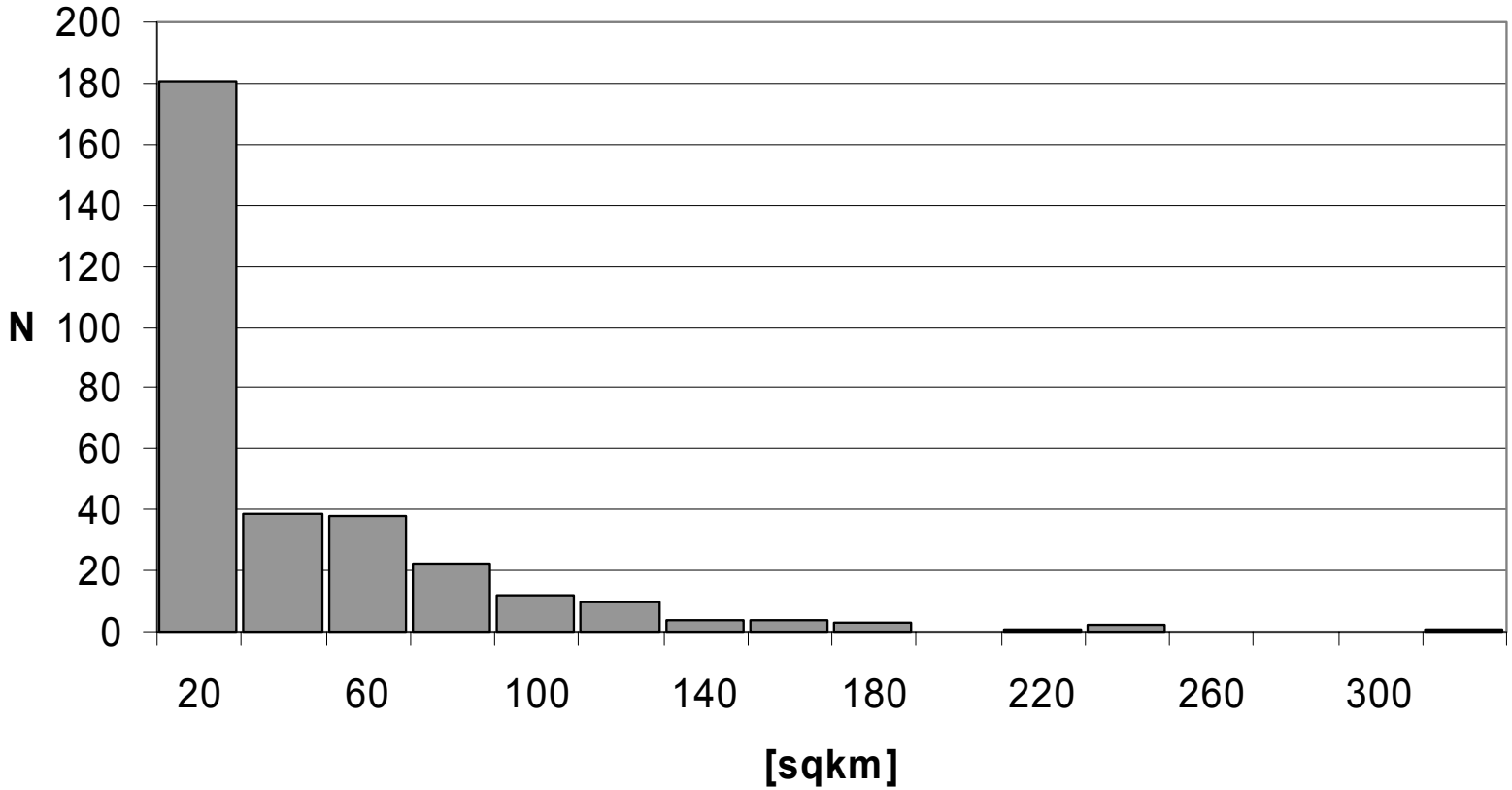
Concept: Routes / Area spanned

Smallest geometry based on all O-D-relations observed (e.g. smallest path)

Measure: Length of geometry / area spanned / buffered area

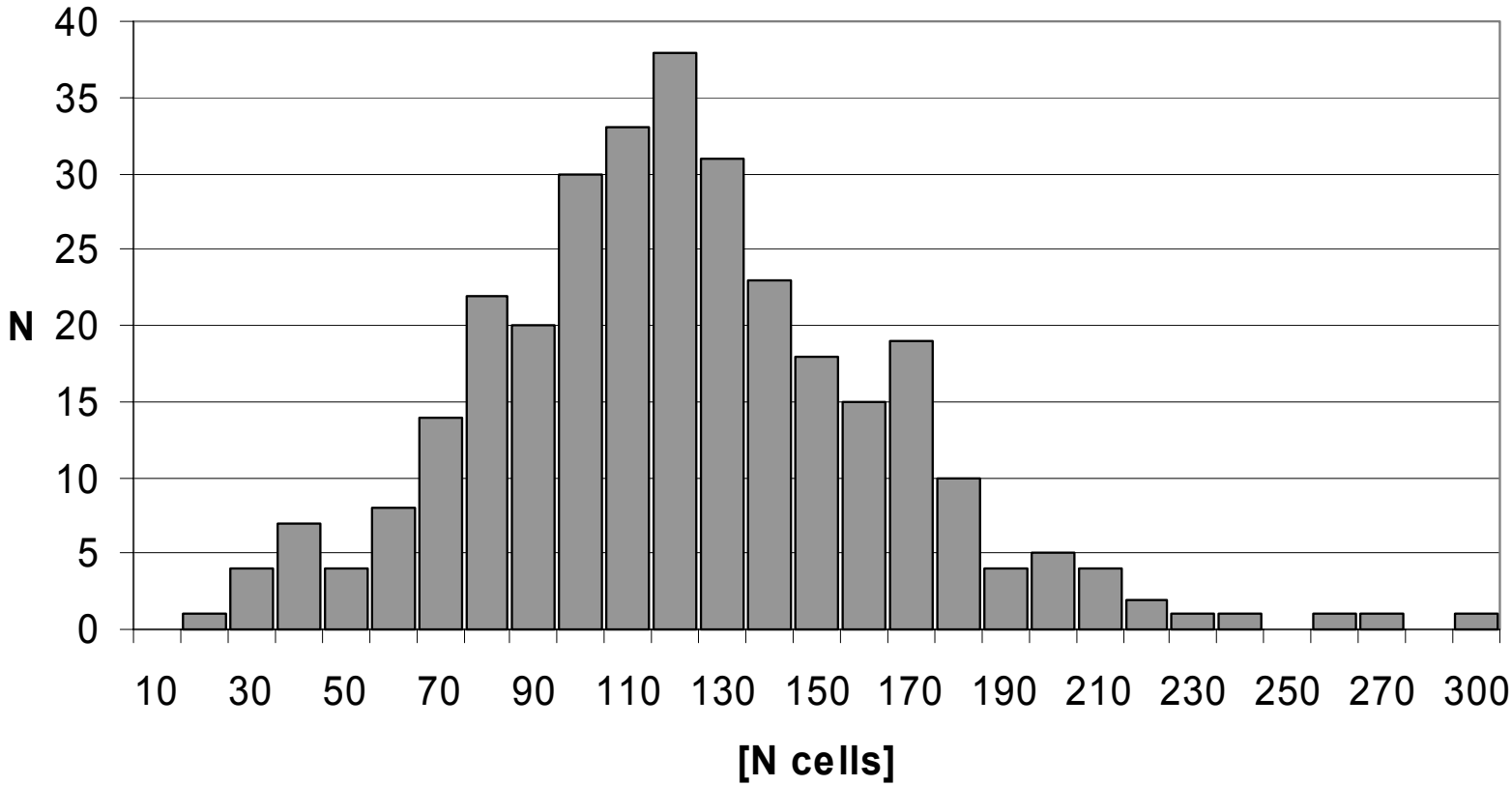
Shows space / network perception

Activity space size variation (1)*



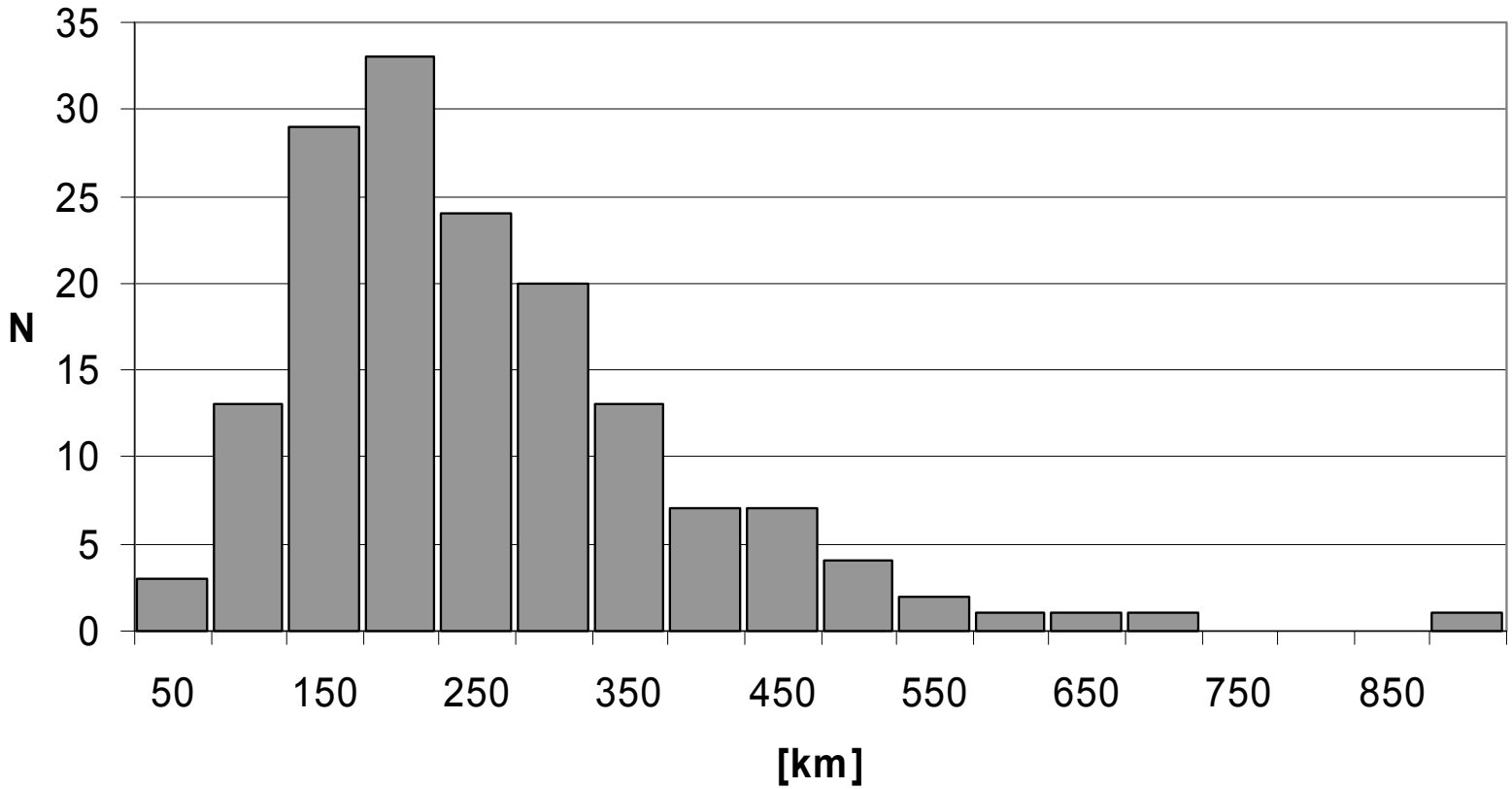
* Local trips only

Activity space size variation (2)*



* “Visited area”, grid cells with positive Kernel densities value [500*500m]

Activity space size variation (3)*



* Minimum network based on observed O-D-relations

Initial results: Determinants of size

No clear picture, but...

+ Amount of mobility (especially kernel densities)
  Number of visited locations

+ Ellipses: Joint effect of household location and intensity car usage

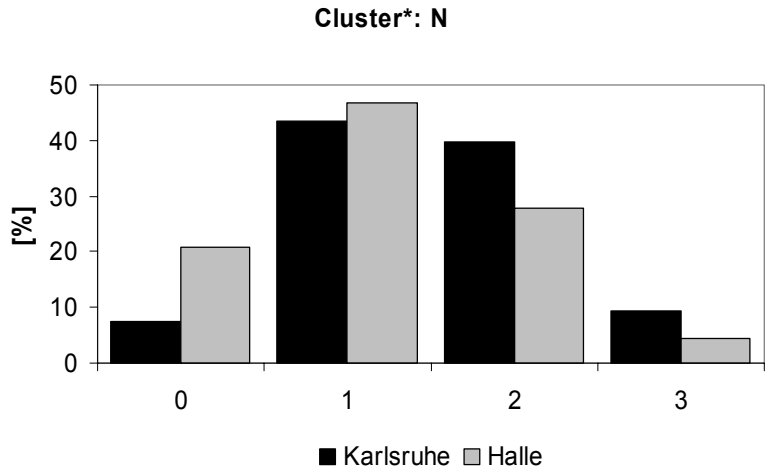
+ Variation within sociodemographic groups differs (minimum spanning trees)

Significant correlation between measures (🡐 travel volumes)

Initial results: Determinants of structure

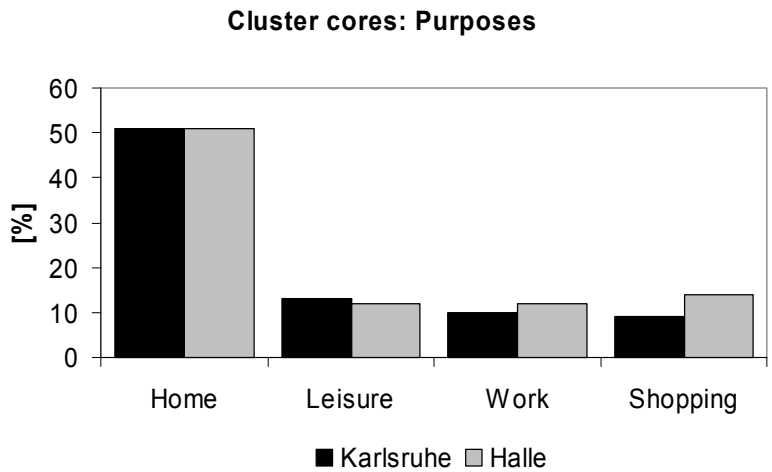
Locational choice stable or variable?

Performing activities at few places:
Combination of activities
in “clusters”



Which purposes as cores?

Workplace as centre nonsignificant?



* e.g. radius: 1000m, minimum 10% of all trips, minimum 3 unique locations in total

Measures assessed

- Flexible
- Easy to implement in G.I.S
- Easy to interpret

Ellipses

Over-generalisation of activity space size due to rigid geometrical form

Kernel densities

Shows proximity between locations, but neglects dispersion and relationships between sub-centres

Minimum spanning trees

Shows dispersion and navigation

Directions of work

Principally: Continuous representation of individual space usage / activity space acceptable?

Accessibility of locations, spatial supply of opportunities: Interactions

Internal structure: What ‘happens’ in and between the subcentres?
Travel times, activity durations, activity chaining

Activity space and destination choice analysis / modelling: Choice set refinement?

References

Rindsfüser, R., T. Perian und S. Schönfelder (2001) Raum-Zeit-Analyse individueller Tätigkeitenprofile - Erste Annäherung auf der Basis einer Längsschnitterhebung (Mobidrive), Stadt Region Land, 71, Tagungsband zum 2. Aachener Kolloqium "Mobilität und Stadt", Institut für Stadtbauwesen und Stadtverkehr, RWTH Aachen, Aachen, 89-106.

Schönfelder, S. and K.W. Axhausen (2002) Measuring the size and structure of human activity spaces – the longitudinal perspective, *Arbeitsbericht Verkehrs- und Raumplanung*, **135**, Institut für Verkehrsplanung und Transportsysteme (IVT), ETH Zürich, Zürich.

Schönfelder, S. and K.W. Axhausen (2002) Activity spaces: Measures of social exclusion?, *Arbeitsbericht Verkehrs- und Raumplanung*, **140**, Institut für Verkehrsplanung und Transportsysteme (IVT), ETH Zürich, Zürich.

Schönfelder, S. and K. W. Axhausen (forthcoming) On the variability of human activity spaces, in M. Koll-Schretzenmayr, M. Keiner und G. Nussabaumer, The Real and Virtual World of Planning, Springer, Berlin.

Borlänge GPS data: A brief overview

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Background: Rättfart Borlänge

- Background: Traffic safety: Swedish Vision Zero approach
- Objective: Speed-limit control by on-board information systems (GPS)
- Aim: Test of acceptance, dynamic speed adaptation
- Implementation: „Intelligent Speed Adaptation“ (ISA), Vägverket
- Case study: Town of Borlänge (SE), appr. 350 “test drivers”
- Original analysis: Traffic psychology, driving behaviour

Secondary use of logg data for travel behaviour research (IVT/ETHZ and ROSO/DMA EPF Lausanne):

- Regularity of travel - Hazard models
- Activity spaces
- Route choice modelling - especially *path size models*

Data availability: GPS and auxiliary

Logg data of 260 vehicles: 190 private test driver, 70 commercial

- Data log every 1 (10) second
- 450.000 all trips (including commercial)
- 250.000 private car trips (Minimum 100, maximum 4000 trips per vehicle), ~50.000 mobile days
- Minimum obs. period: 50 days, maximum: 603 days, mean: 1 year

Data attributes used for secondary analysis: Times (dep./arr.), durations, exact positions, (routes)

Additional data: - Regional road network
- Land-use and POI data (Borlänge kommun)
- Debriefing data (sociodemographics)
- Swedish national travel survey (RES)

Data processing requirements

Aim: Create diary-data-like mobility information

Principally: Definition of minimum quality levels for post-processed data attributes (High, acceptable accuracy, approximations, unavoidable missing data)

(Neglect of non-car travel; only local trips)

Fundamental data post-processing tasks:

Detecting additional or redundant trip ends (J. Wolf, Geostats)

Definite identification of...

- the driver
- unique origins and destinations of travel
- trip purposes

Data processing so far

Initial cleaning of raw data

- Thresholds for minimum/maximum durations, distances etc.
- Consider local trips only

Categorisation and filtering

- Weekdays/weekends, trips to parkings etc.

Identification of trip end positions

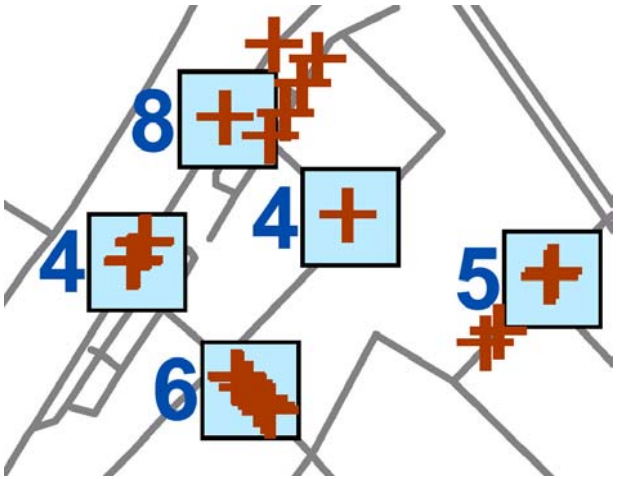
- Aggregating of observed trip ends to unique destinations

Identification of trip purposes

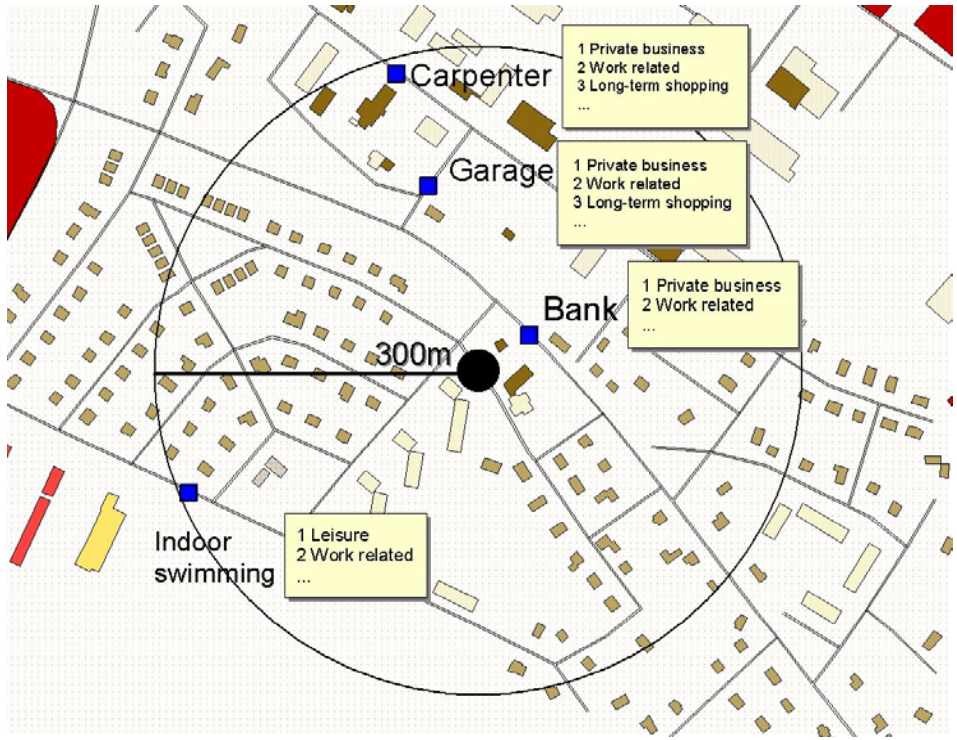
- Unique home and secondary location where known
- Trips ends ➔ land use / POI
- “Temporal matching”: Trip/activity attributes compared to generic data

Data post-processing example

Spatial clustering



Land use comparison



Data post-processing example

Sex	Occupation status	Car availability	Weekday	Activity start time	Activity duration [min]		Most probable activity purpose
M	Self-employed	Always	Monday	20.00	60	➔	Home
M	Self-employed	Always	Monday	20.00	90	➔	Leisure
M	Self-employed	Always	Monday	20.00	150	➔	Leisure
M	Self-employed	Always	Monday	20.00	180	➔	Leisure
M	Self-employed	Always	Monday	20.00	210	➔	Leisure
M	Self-employed	Always	Monday	20.00	240	➔	Leisure
M	Self-employed	Always	Monday	20.00	270	➔	Leisure
M	Self-employed	Always	Monday	20.00	300	➔	Leisure
M	Self-employed	Always	Monday	20.00	330	➔	Home
M	Self-employed	Always	Monday	20.00	360	➔	Home
M	Self-employed	Always	Monday	20.00	420	➔	Leisure
M	Self-employed	Always	Monday	21.00	30	➔	Private business
M	Self-employed	Always	Monday	21.00	60	➔	Leisure
M	Self-employed	Always	Monday	21.00	90	➔	Daily shopping
M	Self-employed	Always	Monday	21.00	150	➔	Leisure
M	Self-employed	Always	Monday	21.00	180	➔	Leisure
M	Self-employed	Always	Monday	21.00	210	➔	Work related

Data processing so far: Initial sample results (1)

28 fulltime workers / 11 retirees (with sufficient debriefing data)

- 19 - 208 mobile days
- 66 - 1185 trips

Compared with cross-sectional reference data (RES):

- Fairly consistent imputation results (number of trips per day, durations, distances etc.)
- Data confirms earlier findings of Mobi*drive* (relationship trips-unique locations, variety seeking)

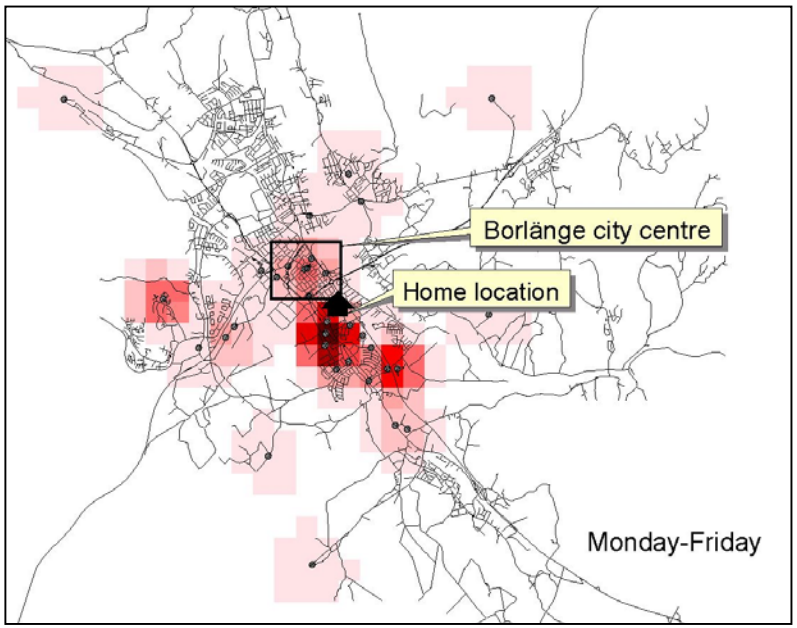
Problems:

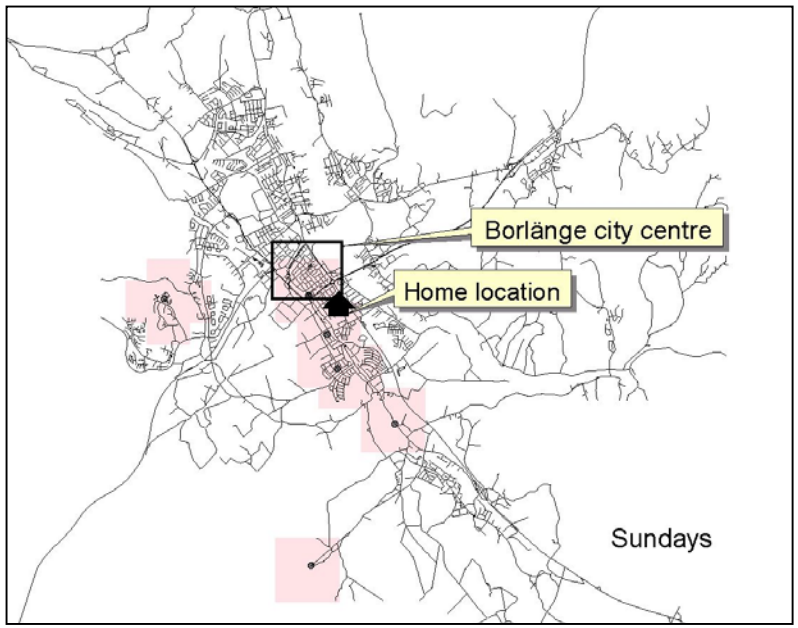
- Trip purposes partly mis-assigned
- Missing back-home trips

Data processing so far: Initial sample results (2)

Identified daily patterns (on respondent):

Activity spaces (Kernel densities):





Data processing - essential next steps

Beforehand detect / remove structural inaccuracy (missing and redundant trips)

Enlarge reference data set

Improve trip purpose assignment to trip ends, i.e. include better land-use / POI data, regularities in travel, combining purpose probabilities (e.g. Bayes) etc.

References

Schönfelder, S., K.W. Axhausen, N. Antille and M. Bierlaire (2002) Exploring the potentials of automatically collected GPS data for travel behaviour analysis - A Swedish data source, in J. Möltgen, and A. Wytzisk (Eds.) GI-Technologien für Verkehr und Logistik, IfGIprints, 13, Institut für Geoinformatik, Universität Münster, Münster, 155-179.

Schönfelder, S. and U. Samaga (2003) Where do you want to go today? - More observations on daily mobility, Presentation at STRC 2003, Ascona, March 2003.