The role of bounded rationality in travel choice behavior and implications for transport modeling

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Outline

• Activity-based transport models
  • Why activity-based and what does it involve?
  • New developments in research

• Aspects of bounded rationality

• Examples of exploring new area
  1. Effect of memory and emotion on learning and satisfaction
  2. Individuals’ mental representations of complex choice problems
  3. Group decision making and joint activity choice
Travel demand models

- Micro simulation models
  - Activity-based models
    - Daily activity-patterns
  - Tour-based models
    - Trip records

- Aggregate trip-based models

Dynamic/static traffic simulation/assignment models

Predicting people’s response to policies is notoriously difficult.
Travel demand models

- Micro simulation models
  - Activity-based models
    - Daily activity-patterns
  - Tour-based models
    - Trip records
    - OD trip matrix

- Aggregate trip-based models

  New model development started in early nineties

  Models are now making the transition to practice

Dynamic/static traffic simulation/assignment models
Why activity-based modeling?

• New demands from transport planning and policy making

• Switch in focus to travel demand measures

• Importance of temporal factors (flexible work hours) and task combination

• Integration of policies: land-use and transport planning

• More comprehensive evaluation of policies
Activity-based versus trip-based approach

**Trip-based**
- Focus is on trips
- Unit is a trip
- Space-time constraints ignored
- Low resolution time and place
- Decision unit is individual
- Predicts when, where, transport mode

**Activity-based**
- Focus is on activities
- Unit is a day
- Space-time constraints taken into account
- High resolution time and place
- Decision unit is household
- Predicts which activities, when, where, for how long, trip-chaining and transport mode
New developments in transportation research

- From static to dynamic models
  - expand time frame from one day to multiple days
  - include life trajectories and long-term mobility decisions

- Include social networks and social interactions
  - social influence in decision making
  - group decision making – negotiation

- New survey methods and data sources
  - tracking of movements with GPS or mobile phone positioning
  - social media – big data
## New survey methods

<table>
<thead>
<tr>
<th>Traditional – diary data</th>
<th>New – GPS tracking</th>
</tr>
</thead>
<tbody>
<tr>
<td>One or two days data</td>
<td>Longer time frame – week or multiple weeks</td>
</tr>
<tr>
<td>Location identification is difficult and imprecise</td>
<td>Location identification is automated and precise</td>
</tr>
<tr>
<td>No recording of travelled routes</td>
<td>Recording of travelled routes</td>
</tr>
<tr>
<td>User unaided in memorizing of activities and modes</td>
<td>Automated interpretation + prompted recall</td>
</tr>
</tbody>
</table>
Aspects of bounded rationality

Habitual life
Learning & judgment

Rational beliefs
versus
Heuristics and memory bias

Adaptation
Activity and mobility patterns & perceived wellbeing

Exploration
Search & info acquisition

No search costs
versus
Sequential search and satisficing behavior

Choice
Evaluation & decision

Absolute utility values
versus
Reference-based utilities and emotional weighting

Needs and resources
- ICT tools
- Social network
- Physical - ICT
- Institutional
- Prices
- Technological

Independent decisions
versus
Social influence and group decision making

Decision utility
versus
Experienced utility
Aspects of bounded rationality

Accounting for bounded rationality requires a change from static to dynamic modeling.
Time is ripe

• Cumulative evidence from psychology and behavioral economics
  • See recent book of Daniel Kahneman (2011) – Thinking, Fast and Slow

• Human biases are well documented and tools for data collection and modeling available

• Modern survey technologies facilitate a move from one-day to multiple days data collection

• Wide use of smart phones allows new in-situ data collection methods
Example of exploring new area (1)

Effect of memory and emotion on learning and satisfaction

How do travelers judge the likelihood of a risky event?

How do travelers judge degree of satisfaction with choice alternatives?
How do travelers judge the likelihood of a risky event?

• This is a relevant question
  • knowing how travelers make likelihood judgements is important for understanding their choice behavior

• Naïve model
  • people count occurrences and store frequency data in memory – their judgments are unbiased

• However, this is not in line with evidence. Two fundamental biases in human likelihood judgements are well-known (Lichtenstein et al., 1978)
Primary bias
• small probabilities are overestimated and large probabilities are underestimated
• this explains why rare events may have a large impact
Secondary bias

- events that are more vividly imagined are overestimated
- this explains why a salient event such as a plane crash tends to have much more impact than a more common event
Availability / fluency heuristic

- first formulated by Tversky and Kahneman (1973)
- supported by numerous empirical studies

Tversky and Kahneman (1973)

- people use a byproduct of memory processes to judge the likelihood of some event
- that is, the ease with which examples of the event can be retrieved from memory is used as criterion
- the easier examples come to mind the more likely the event is judged to be

This heuristic explains the primary and secondary biases (Hertwig et al. 2005)
Model

- ACT-R cognitive architecture provides a model of memory encoding and retrieval processes (Anderson et al. 2004)

\[ A_{ik} = \ln \left( \sum_{j \in k} (t_{ij})^d \right) \]

\[ Q_{ik} = \frac{A_{ik}}{\sum_j A_{ij}} \]

- This model explains the primary bias
Model

- Extension of the ACT-R memory model to account for effect of arousal on memory

\[ A_{ik} = \ln \left( \sum_{j \in k} (t_{ij})^{d(S)} \right) \]

\[ Q_{ik} = \frac{A_{ik}}{\sum_j A_{ij}} \]

- This model also explains the secondary bias
How do travelers judge degree of satisfaction with choice alternatives?

• This is a relevant question
  • knowing how travelers arrive at satisfaction judgements is important for understanding subjective wellbeing and habitual behavior

• Naïve model
  • decision utility is the same as experienced utility
    ➢ utilities can be derived from choice behavior

• However, Kahneman (2000) points to known biases:
  • neglect of duration of episodes
  • dominance of end outcome of episodes
  • disproportional impact of peak experiences
Model

• Again, the memory model of ACT-R offers a way to describe this process

\[ A_{ij} = \ln \left( (t_{ij})^{d(S)} \right) \]

\[ U_i = \sum_j A_{ij} \cdot U_{ij} \]

• This model explains the disproportional impact of extreme events on satisfaction
What data do we need to test and estimate the models and how can the data be collected?

Data collection

- In-situ measurement of affective experiences of travelers (Ettema et al. 2014)
- Small questionnaire on the smartphone completed on every trip
  - data of the trip (mode, route, purpose, etc.)
  - emotional state of the traveller during the trip (arousal and valence)
  - satisfaction judgment (experienced utility)
What are the implications for policy making and transport modeling?
Implications

- **Policy making - theory stresses:**
  - importance of reliability of transport services on satisfaction and judgement
    - avoid negative peak experiences
  - importance of avoiding losses in the behavior change targeted
    - losses generate negative emotion

- **Transport modeling**
  - the memory-based models of learning and judgement can be incorporated in dynamic travel-demand models
Example of exploring new area (2)

What’s in a person’s mind?

Individuals’ mental representations of complex choice problems

Joint work with Benedict Dellaert, Erasmus University Rotterdam
Measuring mental representations

In earlier work, Dellaert et al. (2008) and Arentze et al. (2008) conceptualized MRs as a causal network

The representations are constructed for the choice problem at hand; they determine how the individual evaluates choice alternatives.
Example - shopping

Attributes:
- Location
  - Crowded
  - Prices
  - Store variety
- Transport mode
  - Travel time
  - Transfers

Benefits:
- Pleasant
- Goal success

Decisions:
- Location
- Transport mode

Utility
<table>
<thead>
<tr>
<th>Comparison to standard model</th>
<th>New approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard model</td>
<td>New approach</td>
</tr>
<tr>
<td>Attributes of alternatives are assumed as given</td>
<td>Attribute selection is part of the model</td>
</tr>
<tr>
<td>No information about underlying reasons</td>
<td>Benefits underlying attribute evaluation are part of the model</td>
</tr>
<tr>
<td>Mental costs of evaluation are not taken into account</td>
<td>Mental costs of evaluation are taken into account</td>
</tr>
<tr>
<td>Data about attributes are collected in focus groups</td>
<td>Mental representations are measured by an automated interview technique</td>
</tr>
<tr>
<td><strong>Hybrid choice model</strong></td>
<td><strong>New approach</strong></td>
</tr>
<tr>
<td>-------------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Psychological factors are taken into account as latent variables</td>
<td>Mental representations are taken into account</td>
</tr>
<tr>
<td>Psychological factors are attitudes or perceptions influencing preferences</td>
<td>Mental representations are causal networks for reasoning about a choice problem</td>
</tr>
<tr>
<td>Psychological factors are stable person characteristics</td>
<td>Mental representations are activated in a situation</td>
</tr>
</tbody>
</table>
Measurement of MRs

• CNET – interview technique of open-response elicitation

--- Example ---

• Imagine a situation where you plan to make a shopping trip

• When you choose between Car, Bus and Bike
  - What are your considerations?
  - Why is it important?

- Attributes

- Benefits

- Choice

In contrast to existing laddering techniques – CNET is decision oriented
Imagine the following setting

Alternatives are presented for
- where to shop
- when to shop (time of day)
- which transportation mode

You need to do grocery shopping activity on a working day

<table>
<thead>
<tr>
<th></th>
<th>walk (min)</th>
<th>bicycle (min)</th>
<th>car (min)</th>
<th>bus (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home-neighborhood center</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Home-regional shopping center</td>
<td>35</td>
<td>15</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>Home-work</td>
<td>50</td>
<td>20</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Home-city center</td>
<td>25</td>
<td>9</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>Work-city center</td>
<td>25</td>
<td>9</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>Work-regional shopping center</td>
<td>35</td>
<td>12</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>City center-regional shopping center</td>
<td>25</td>
<td>9</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>City center-parking 1+2</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Imagine the following setting

Alternatives for location
- a week market
- a corner store
- a supermarket

Alternatives for mode
- car
- bicycle
- bus

Alternatives for time-of-day
- during lunch
- after work
- in evening

Travel times by mode

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Imagine the following setting

Experiment

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<tr>
<td>Home-neighbourhood</td>
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<td>35</td>
<td>15</td>
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<td>15</td>
</tr>
<tr>
<td>Shopping center</td>
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**Base scenario**
only the physical shopping alternatives are available

**e-Commerce scenario**
On-line shopping alternative is added

Subjects are randomly allocated to a scenario
Empirical application (Horeni et al. 2010, 2014)

• Representative sample of 666 individuals from a Dutch panel

• Scenarios
  • Base
  • Uncertainty - product availability and travel time
  • High Consequences - boss over for dinner
  • e-Commerce

• Respondents were randomly allocated to a scenario
Example of an MR

Weather

Transport mode choice

Choice of shopping time

Choice of grocery store

Travel time

Available time to shop

Low effort shopping

Crowdedness in stores

Number of stores

Shopping success

Legend:
- Decision Variable
- Situational variable
- Attribute
- Benefit
- Causal link
Results - contents of MRs

Attributes

- available product assortment
- distance from current location
- number of bags to carry
- accessibility of the store
- parking opportunities
- price level of the assortment
- non-interpretable/unclear
- leisure time
- available time to shop
- simplicity of the travel route
- recreation time during work
- conflict with other arrangements
- weather
- product quality
- availability of the TM
- travel time
- crowdedness in the store
- capacity of the TM
- working hours
- required time to shop
- durability of bought products
- habituation to the TM
- time pressure
- possibility to store shoppings
- necessity
- combination with other activities
- sort of bought products
- familiarity with the SL

- e-commerce scenario
- basic scenario

most frequent attributes same in both scenarios

In base scenario more frequent

In e-commerce scenario more frequent

In general there is little variation between both scenarios with regard to the nature of attributes

The differences are not significant on a 5% level
Results - contents of MRs

Benefits

- personal care
- safety in the shopping location
- social acceptance
- taste experience
- environmental protection
- attractiveness of the shopping environment
- course of fitness/wellbeing
- health
- shopping comfort
- travel pleasure
- diversity in product choice
- financial savings
- mental ease
- shopping pleasure
- travel comfort
- time savings
- ease of shopping
- ease of travelling
- relaxation/recreation
- shopping success
- health
- travel comfort
- diversity in product choice
- shopping success
- mental ease
- shopping pleasure
- travel comfort
- time savings
- ease of shopping
- personal care

General tendency

the benefits have higher frequencies in the e-commerce scenario

Significantly more frequent

receive little attention in shopping trip choice

most frequent benefits in both scenarios
Some substantive findings

• Most important considerations in scheduling the shopping trips are
  − Shopping success, travel ease, time savings, shopping ease, and financial savings

• Situational conditions varied have
  − Little influence on attributes activated
  − Significant influence on
    − Relative importance of the benefits and
  − Some influence on how attributes influence benefits

• Considerable variation exists between individuals in terms of their mental costs in the formation of mental representations
Model development - MR

1. Basic building block is a D – A – B chain

2. Value of including a D – A – B chain
   - \textit{Gain}: reduction of risk of making wrong decision
   - \textit{Costs}: mental effort required for including in evaluation

3. Risk of making the wrong decision
   - Utility variance caused by the decision variable
Logit model of MR activation

Net utility of activating a D-A-B chain in situation $n$

$$u_{hijn} = \alpha_{jn} \cdot s_{ijn} \cdot s_{hin} \cdot sd(r_{hijn}) - \theta_n + \epsilon_{hijn}$$

Probability of activating a D-A-B chain follows binary logit specification

Extended to allow for heterogeneity in mental costs ($\theta_{nc}$) and base line alternative preferences.
Conclusions

• Model of mental representations combines
  • utility-based theories of choice
  • mental-model theories of cognition

• The model reveals situational dependence of:
  • which attributes used in evaluation
  • for what benefits
  • trade-off with mental costs

• Data collection need to be expanded to cover also activated mental representations in a choice task
Group decision making
- joint activity choice

Example of exploring new area (3)

A negotiation model of group decision making
## Modeling joint activity choice

<table>
<thead>
<tr>
<th>Standard model</th>
<th>New approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interactions between persons within households</td>
<td>Extended to social networks of persons</td>
</tr>
<tr>
<td>Assumes a group utility function</td>
<td>No group utility function, just individual preferences</td>
</tr>
<tr>
<td>Ignores the process of group decision making</td>
<td>Assumes a negotiation process</td>
</tr>
<tr>
<td>Rational model</td>
<td>Bounded rationality – human biases</td>
</tr>
</tbody>
</table>
Background and objective

• Recent work on group decision making in travel behavior research
  • agent-based modeling (Ma et al. 2011, 2012)
  • stated-choice experiments a.o.
    – household location choice (Molin et al. 1999)
    – logistics supply chains (Hensher et al. 2007)
    – household vehicle purchase (Beck et al. 2012)

• This is an emerging field in travel behavior research – many aspects

• The purpose of this study (Arentze 2014) is to empirically estimate a model of group decision making
Framework – process model

• Assumptions of the group process
  • persons communicate the preferences for choice options among each other
  • they do proposals and respond to proposals of others until agreement is reached

• Characteristics of the process
  • no group utility function
  • no central controller
  • persons know each others preferences
  • group decision is the result of group interaction
Theory and hypothesis

• When doing proposals or responding to proposals individuals have to take into account preference differences

• Findings from bargaining studies in social psychology
  • fairness plays an important role
  • asymmetry in behavior (Loewenstein et al. 1989)
    - fairness more important when negotiation is about costs a.o.t rewards
The social utility function

The social utility person $k$ assigns to a proposal $i$

$$U_{ik} = \beta_{1k} \cdot Z_{ik} + \beta_{2k} \cdot \sum_{m \neq k} Z_{im} + \beta_{3k} \cdot D(Z_i)$$

- Own preference value
- Preference values of others
- Differences preference values across the group

when it is a proposal from someone else

$$U_{ik} = \beta_{0k} + \beta_{1k} \cdot Z_{ik} + \beta_{2k} \cdot \sum_{m \neq k} Z_{im} + \beta_{3k} \cdot D(Z_i)$$

Added constant: basic inclination to follow someone else
Joint choice task – doing a proposal

Imagine you are planning a joint activity with two friends

Three options for the activity have been identified

The preferences in the group are as follows

<table>
<thead>
<tr>
<th></th>
<th>Activity A</th>
<th>Activity B</th>
<th>Activity C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yourself</td>
<td>9</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Friend 1</td>
<td>5</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>Friend 2</td>
<td>5</td>
<td>7</td>
<td>9</td>
</tr>
</tbody>
</table>

Which proposal would you do?
- Activity A
- Activity B
- Activity C

Maximizes own outcome
Maximizes group outcome
Joint choice task – doing a proposal

Another example

The preferences in the group are as follows

<table>
<thead>
<tr>
<th></th>
<th>Activity A</th>
<th>Activity B</th>
<th>Activity C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yourself</td>
<td>5</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>Friend 1</td>
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<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Friend 2</td>
<td>5</td>
<td>9</td>
<td>7</td>
</tr>
</tbody>
</table>

Which proposal would you do?

- Activity A
- Activity B
- Activity C

Maximizes group and own outcome

Equal outcomes
Joint choice task – variant

This time one of the friends does a proposal

The preferences in the group are as follows

<table>
<thead>
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<th></th>
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</tr>
</thead>
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<tr>
<td>Yourself</td>
<td>9</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Friend 1</td>
<td>5</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>Friend 2</td>
<td>5</td>
<td>7</td>
<td>9</td>
</tr>
</tbody>
</table>

Friend 1 proposes to do: **Activity B**

What would you do?
- Accept the proposal
- Do another proposal, namely
  - Activity A
  - Activity C
Joint choice task – variant

This time the travel times differ

The travel times for the group are as follows

<table>
<thead>
<tr>
<th></th>
<th>Location A</th>
<th>Location B</th>
<th>Location C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yourself</td>
<td>5</td>
<td>15</td>
<td>25</td>
</tr>
<tr>
<td>Friend 1</td>
<td>5</td>
<td>25</td>
<td>15</td>
</tr>
<tr>
<td>Friend 2</td>
<td>25</td>
<td>15</td>
<td>5</td>
</tr>
</tbody>
</table>

Which proposal would you do?
- Location A
- Location B
- Location C
Sample and data collection

- 315 persons participated
- Random sample from a national panel
- Each person received
  - 8 tasks – 4 x initiating and 4 x responding
- Scenarios
  - Activity versus travel time
  - High versus low consequences
- Outcome tables were varied by an efficient design
### Results – basic MNL model

#### Activity

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value (β)</th>
<th>t-value (β)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-interest ((\beta_1))</td>
<td>0.532</td>
<td>14.0</td>
</tr>
<tr>
<td>Other ones interest ((\beta_2))</td>
<td>0.319</td>
<td>11.1</td>
</tr>
<tr>
<td>Inequity ((\beta_3))</td>
<td>-1.16</td>
<td>-11.9</td>
</tr>
<tr>
<td>Proposal status ((\beta_0))</td>
<td>0.928</td>
<td>9.21</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scale - small consequences</th>
<th>Value (β)</th>
<th>t-value (β)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale - large consequences</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

#### Travel time

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value (β)</th>
<th>t-value (β)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-interest ((\beta_1))</td>
<td>-0.063</td>
<td>-9.55</td>
</tr>
<tr>
<td>Other ones interest ((\beta_2))</td>
<td>-0.027</td>
<td>-7.01</td>
</tr>
<tr>
<td>Inequity ((\beta_3))</td>
<td>-0.215</td>
<td>-10.5</td>
</tr>
<tr>
<td>Proposal status ((\beta_0))</td>
<td>1.58</td>
<td>13.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scale - small consequences</th>
<th>Value (β)</th>
<th>t-value (β)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale - large consequences</td>
<td>0.608</td>
<td>-4.72</td>
</tr>
</tbody>
</table>

Parameter scale correction

- Inequity / self = 2.18
  - Equity plays a significant role
  - Equity has a bigger influence

- Inequity / self = 3.40
  - Proposal status plays a significant role
  - Proposal status has a bigger influence
## Results – discrete mixture model

### Activity

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mass point</th>
<th>Value (β)</th>
<th>t-value (β)</th>
<th>Probability (π)</th>
<th>t-value (π)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-interest (β₁)</td>
<td>1</td>
<td>1.10</td>
<td>11.3</td>
<td>0.687</td>
<td>10.8</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0.062</td>
<td>0.74</td>
<td>0.313</td>
<td>4.94</td>
</tr>
<tr>
<td>Other ones interest (β₂)</td>
<td>1</td>
<td>0.718</td>
<td>8.74</td>
<td>0.777</td>
<td>13.8</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>-0.085</td>
<td>-1.27</td>
<td>0.223</td>
<td>3.95</td>
</tr>
<tr>
<td>Inequity (β₃)</td>
<td>1</td>
<td>0.250</td>
<td>0.85</td>
<td>0.288</td>
<td>4.62</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>-2.50</td>
<td>-9.03</td>
<td>0.712</td>
<td>11.4</td>
</tr>
<tr>
<td>Proposal status (β₀)</td>
<td>1</td>
<td>1.17</td>
<td>7.92</td>
<td>0.930</td>
<td>25.7</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>5.80</td>
<td>3.73</td>
<td>0.070</td>
<td>1.94</td>
</tr>
</tbody>
</table>

### Travel time

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mass point</th>
<th>Value (β)</th>
<th>t-value (β)</th>
<th>Probability (π)</th>
<th>t-value (π)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-interest (β₁)</td>
<td>1</td>
<td>-0.020</td>
<td>-1.64</td>
<td>0.525</td>
<td>7.11</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>-0.190</td>
<td>-8.39</td>
<td>0.475</td>
<td>6.43</td>
</tr>
<tr>
<td>Other ones interest (β₂)</td>
<td>1</td>
<td>-0.121</td>
<td>-5.26</td>
<td>0.364</td>
<td>3.46</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>-0.019</td>
<td>-2.11</td>
<td>0.636</td>
<td>6.04</td>
</tr>
<tr>
<td>Inequity (β₃)</td>
<td>1</td>
<td>-0.601</td>
<td>-9.02</td>
<td>0.550</td>
<td>6.74</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>-0.079</td>
<td>-1.80</td>
<td>0.450</td>
<td>5.51</td>
</tr>
<tr>
<td>Proposal status (β₀)</td>
<td>1</td>
<td>8.19</td>
<td>5.95</td>
<td>0.261</td>
<td>5.08</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1.39</td>
<td>6.98</td>
<td>0.739</td>
<td>14.42</td>
</tr>
</tbody>
</table>

There is considerable heterogeneity
Social styles

Meaningful styles can be defined as particular combinations of parameter mass points

<table>
<thead>
<tr>
<th></th>
<th>Self interest</th>
<th>Others interest</th>
<th>Fairness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balanced</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Selfish</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Altruistic</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Social</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Rational</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Identification of styles

- assign each case to the pattern that maximizes the likelihood of the choice observations
Results

- **Balanced style:** self & others & equity
- **Rational style:** self & others
- **Selfish style:** self
- **Social style:** equity, equity & self / others
- **Else:** others; none

**Strong asymmetry**

**Activity**
Balanced style dominates

**Travel time**
Social style dominates
## Style memberships: estimation results MNL model

<table>
<thead>
<tr>
<th>Style</th>
<th>Parameter</th>
<th>Activity</th>
<th></th>
<th>Travel time</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Value</td>
<td>t-value</td>
<td>Value</td>
<td>t-value</td>
</tr>
<tr>
<td>Balanced</td>
<td>Constant</td>
<td>1.67</td>
<td>5.95</td>
<td>-0.762</td>
<td>-2.35</td>
</tr>
<tr>
<td>Rational</td>
<td>Constant</td>
<td>0.074</td>
<td>0.19</td>
<td>-0.819</td>
<td>-1.99</td>
</tr>
<tr>
<td></td>
<td>age &lt; 35 years</td>
<td>0.230</td>
<td></td>
<td>0.309</td>
<td>0.69</td>
</tr>
<tr>
<td></td>
<td>age 35 -&lt; 55 years</td>
<td>-1.28</td>
<td>-2.49</td>
<td>0.309</td>
<td>0.69</td>
</tr>
<tr>
<td></td>
<td>age 55+ years</td>
<td>1.05</td>
<td>2.94</td>
<td>1.06</td>
<td>2.49</td>
</tr>
<tr>
<td>Selfish</td>
<td>Constant</td>
<td>-1.10</td>
<td>-2.13</td>
<td>-0.693</td>
<td>-2.19</td>
</tr>
<tr>
<td>Social</td>
<td>Constant</td>
<td>0.847</td>
<td>2.75</td>
<td>1.02</td>
<td>4.69</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td></td>
<td></td>
<td>-0.541</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>0.541</td>
<td>3.29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Else</td>
<td>Constant</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adjusted rho-square</td>
<td>0.207</td>
<td>0.169</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Older age group more often rational style**

**Females more often social style in case of travel times**
Conclusions

• Considerable heterogeneity in styles
• Group process bias
  • fairness (equity) is important
  • process is important (proposal status)
  • asymmetry costs and rewards

• Implications
  • people favor equity for joint activities / travel
  • e.g., they are willing to travel further when this leads to more equal distribution of travel times

• The new model of joint activity choice takes process bias into account
Future research

• The model can be incorporated in activity-based models to predict joint activity choice

• Simulations must be conducted to explore the properties of the model
  • extent to which it has an impact on outcomes

• It is interesting to see if the model can be validated based on revealed preference data

• The model is basic – extensions in many directions are possibly fruitful
Conclusions - overall

- Bounded rationality is important in
  - Learning & judgment
  - Search & information acquisition
  - Decision making
  - Subjective wellbeing
  - Social life

- Examples of exploring new area were given
  - memory and emotion
  - mental representations
  - negotiation in group decision making
Literature references

**Mental representations**


**Group decision making**


Memory and emotion effects


Thank you for your attention

Questions