Elderly's Potential Action Space: Using Activity-Based Approach to review quality of life—An Experiment in Tainan

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Presenter: Huang, Ding-Jhong
Outline

- **Introduction**
  - Research Background
  - Research Gap
  - Research Question
- **Research Design**
- **Data/Model Analysis**
  - Activity-travel pattern
  - TTRs of various groups
  - Multiple regression analysis
  - Potential action space and application
- **Conclusion and Recommendation**
Introduction—Background

- In developed countries, to response to aged society, planners have to improve “accessibility” and “mobility” of the elderly through transport planning.
- Opportunities for the older to attend outdoor activities influence the QoL of them.

<table>
<thead>
<tr>
<th>Region / Age</th>
<th>Under 15</th>
<th>15 to 64</th>
<th>Over 65</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taiwan</td>
<td>13.99%</td>
<td>74.02%</td>
<td>11.99%</td>
</tr>
<tr>
<td>Tainan city</td>
<td>14.09%</td>
<td>74.91%</td>
<td>11.00%</td>
</tr>
</tbody>
</table>
Introduction—Research gap

• **Aggregate trip-based model** like 4-steps modelling method failed to recognise transport as a derived demand of an activity and ignore the differences among people (Schmöcker et al., 2005).

• The research focused on the elderly only covered descriptive statistics, trip generation rate prediction, trip length, modal choice, and trip chain analysis (Rosenbloom, 2001, Collia, Sharp and Giesbrecht, 2003, Newbold et al., 2005).

• The elderly were regarded as *homogenous* group; however, some elderly people shows no difference from younger group (Alsnih and Hensher, 2003).

Therefore, this research will be:

• **Disaggregate research**, to explore individual activity and travel behaviour.

• **Activity-based**, regarding transport as derived demand of activity participation. Collect **travel diary data** and based on time geography to build personal potential action space.
Introduction—Research Question

① What is the “Willingness to move” for elderly people to attend certain activities?
② What is the mechanism behind “Willingness to move” and how to quantify?
③ How to use measured “Willingness to move” to support spatial planning”?

By developing
① Elderly people aimed travel behaviour database
② Activity-classified travel time ratio of elderly people
③ Activity & mode-categorised potential action space of elderly people

To provide
• Reference for decision-makers to plan for elderly people
• Foundation for further studies about elderly people’s travel behaviour
Research Design

Theory and concept:
1. Replace Place-based accessibility by Person-based accessibility (Hägerstrand, 1970)
2. Based on time geography, explore how people make transport decision under spatial-temporal restrictions (Kwan, 1998)
3. Assume activity scheduling and individual attributes contribute more to travel behaviour than built environmental factors. (Schwanen and Dijst, 2002)
Method: Activity-based approach

1. What is the difference of ABA from trip-based approach?
2. Composed by activity participation scheduling, transport decision, household role and dynamic analysis (Pas, 1985)
3. Activity travel diary questionnaire as major data collection method
## Research Design-questionnaire

Composed by 5 parts:

<table>
<thead>
<tr>
<th>Part</th>
<th>Description</th>
</tr>
</thead>
</table>
| ①    | Individual and family background data survey  
  *e.g.*: Gender, age, address (Post code), employability, Household role, etc. |
| ②    | Travel behaviour  
  *e.g.*: Car ownership, public transport usage, ability to walk, etc. |
| ③    | Instrumental activities of daily living (IADL) |
| ④    | Activity preference  
  - Enquiring respondent about their activity preference |
| ⑤    | Travel diary survey (24 hours/ A day)  
  - Recording participant’s daily activities, scheduling, place, mode, etc |
Research Design

Activity-travel pattern:
1. Replaced trip as basic analysis unit
2. Composed by journeys, destinations, travel order and modal choice
3. **Scheduling** as main focus (Wen, Chieh-Hua, Koppelman, FrankS, 2000)
4. **Time windows** are disposable time after scheduling fixed activities (e.g. mandatory/restrictive activities), and those flexible time windows are where discretionary activity-travel behaviour take place.

Example: A worker’s daily activity-travel pattern
Travel time ratio:

1. Main variable for “potential action space”, others are activity type and location, available time, travel speed.

2. Assume trade-off exists between travel time and activity duration (Susilo & Dijst, 2009)

3. Regard transport as derived demand for activity participation but not simply negative factor.

I: Stay in base without moving
II: Typical situation
III: Infeasible travel plan
IV: Moving without joining activity

Outdoor and indoor activity participation space-time prism
Source: (Ohmori et al., 1999)
Activity travel pattern classification:

- The elements of outdoor activity-travel pattern are tours composed by destinations including home, work and activity place and travel order.
- Before calculating TTR, clear definition for destination and complete journey must be made.

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Visualisation</th>
<th>Meaning</th>
<th>Legend</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>○→○</td>
<td>No specific activity place in outdoor activity</td>
<td>○home</td>
</tr>
<tr>
<td>1</td>
<td>○→●→○</td>
<td>Single activity place in outdoor activity</td>
<td>●Activity site</td>
</tr>
<tr>
<td>2</td>
<td>○→⊙→○</td>
<td>Commuting activity</td>
<td>○Working site</td>
</tr>
<tr>
<td>3</td>
<td>○→●→●→○</td>
<td>Plural activity places in outdoor activity</td>
<td>→Travel</td>
</tr>
<tr>
<td>4</td>
<td>○→⊙→●→○</td>
<td>Additional stop when commuting activity</td>
<td></td>
</tr>
</tbody>
</table>

Note: There is no identifiable activity duration in type 0, so type 0 is excluded from the following studies.
Travel time ratio calculation:
• The operationalization of TTR is to divide travel time by whole activity-travel duration. Some examples beside demonstrate how TTR is calculated when journeys are complicated (more than one activity place or one base.)

\[
\tau = \frac{15 + 15}{(15 + 15) + 30} = 0.5
\]

\[
T'_1 = (20 + 10) - \text{basic } T_t
\]

\[
\tau = \frac{(20 + 10) - \text{basic } T_t + 20}{35} = 0.429
\]

\[
T'_1 = (60 \text{ min } ) \times \frac{40}{40 + 80 + 40} = 15 \text{ min}
\]

\[
T'_2 = 30 \text{ min } T'_3 = 15 \text{ min}
\]

\[
\tau_1 = \frac{15}{15 + 40} = 0.27
\]

\[
\tau_2 = \frac{30}{30 + 80} = 0.27
\]

\[
\tau_1 = \frac{12}{12 + 30} = 0.286
\]

\[
\tau_2 = \frac{8}{8 + 20} = 0.286
\]

Data Processing
Data Processing

Potential action space:

- After TTR is calculated, with expected activity duration, mode speed and living location will shape the potential action space of elderly people.

Outdoor and indoor activity participation space-time prism
Source: (Ohmori et al., 1999)
Data analysis

Activity-travel pattern

- Older people produce more shorter journey, but still arrange 1/3 activity participations in trip chaining.

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Visualising</th>
<th>Meaning</th>
<th>No. of Journey</th>
<th>Place stayed (Activity participation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>○→●→○</td>
<td>Non-working journey</td>
<td>358</td>
<td>358</td>
</tr>
<tr>
<td>2</td>
<td>○→○→○</td>
<td>Working journey</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>3</td>
<td>○→●→●→○</td>
<td>Non-working chaining journey</td>
<td>71</td>
<td>151</td>
</tr>
<tr>
<td>4</td>
<td>○→○→○→○</td>
<td>Working &amp; business chaining journey</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>○→●→○→○</td>
<td>Working chaining journey</td>
<td>9</td>
<td>30</td>
</tr>
</tbody>
</table>

Total: 459 journeys, 560 activity participations

Legend
- ○ home
- ● Activity site
- ○ Working site
- → Travel
Data analysis

Activity-travel pattern

- Available time are divided by mandatory activities like sleeping and dining.
- Outdoor activities mainly take place in the morning and afternoon.

Time allocation of elderly people

Non-sleeping time allocation of elderly people
Data analysis

Travel time ratio

- Female, aged over 75, single trip, private vehicles dependent, accompanied trips demonstrate higher TTRs.
- Higher TTRs might result from shorter activity duration (for aged over 75 and walking trips) or longer travel time (for female, bus trip) or in both ways (for single trip)
- Various activities show TTRs in great difference
Data analysis

Multiple regression analysis

- This research builds a multiple hierarchical regression model with TTR as dependent variable, five groups of independent variables. Based on literature review, this study enters variables according to order of importance
- Activity attributes (types and scheduling) influence TTR the most

**Model Summary**

<table>
<thead>
<tr>
<th>All data model</th>
<th>R</th>
<th>R Square</th>
<th>Change Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>R Square Change</td>
</tr>
<tr>
<td>1 (Activity type/scheduling)</td>
<td>.581 (^a)</td>
<td>.337</td>
<td>.337</td>
</tr>
<tr>
<td>2 (Trip characteristics)</td>
<td>.619 (^b)</td>
<td>.383</td>
<td>.045</td>
</tr>
<tr>
<td>3 (Socio-economic attributes)</td>
<td>.629 (^c)</td>
<td>.396</td>
<td>.013</td>
</tr>
<tr>
<td>4 (Living ability)</td>
<td>.640 (^d)</td>
<td>.410</td>
<td>.014</td>
</tr>
<tr>
<td>5 (Built environment)</td>
<td>.649 (^e)</td>
<td>.421</td>
<td>.012</td>
</tr>
</tbody>
</table>

**Grouped variables**

<table>
<thead>
<tr>
<th>1 (Activity type/scheduling)</th>
<th>Activity-travel time</th>
<th>Indoor non-sleeping time</th>
<th>Mandatory activity</th>
<th>Restrictive activity</th>
<th>Activity preference</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 (Trip characteristics)</td>
<td>Journey type</td>
<td>Accompanied</td>
<td>No. of journeys</td>
<td>Private motor vehicle</td>
<td></td>
</tr>
<tr>
<td>3 (Socio-economic attributes)</td>
<td>Married</td>
<td>High-education level</td>
<td>Working</td>
<td>Housework sharing</td>
<td>Household size</td>
</tr>
<tr>
<td>4 (Living ability)</td>
<td>Disposable income</td>
<td>Age</td>
<td>IADL</td>
<td>Ability to walk</td>
<td></td>
</tr>
<tr>
<td>5 (Built environment)</td>
<td>Local population density</td>
<td>District population density</td>
<td>Distance from district centre</td>
<td>Infrastructure within 400 metres</td>
<td></td>
</tr>
</tbody>
</table>
Data analysis

Multiple regression analysis

- Activity-travel time, Mandatory, Restraint activity, Accompanied, High-education level, Number of family have significantly positive impact on TTRs
- Activity-travel time, Trip chaining, Disposable income, Local population density have significantly negative impact on TTRs

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Std. Error of the Estimate</th>
<th>Durbin-Watson</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear regression</td>
<td>0.649</td>
<td>0.421</td>
<td>0.404</td>
<td>0.104</td>
<td>1.648</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficients</th>
<th>t-statistics</th>
<th>Variables</th>
<th>Coefficients</th>
<th>t-statistics</th>
<th>Variables</th>
<th>Coefficients</th>
<th>t-statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>-1.9606</td>
<td>-7.1786***</td>
<td>Married</td>
<td>0.1161</td>
<td>1.9318*</td>
<td>Local population density</td>
<td>-0.0080</td>
<td>-2.6441***</td>
</tr>
<tr>
<td>Activity-travel time</td>
<td>-0.0031</td>
<td>-11.1195***</td>
<td>High-education level</td>
<td>0.2134</td>
<td>2.0352 **</td>
<td>District population density</td>
<td>0.0110</td>
<td>1.9521 *</td>
</tr>
<tr>
<td>Indoor non-sleeping time</td>
<td>0.0007</td>
<td>3.8880***</td>
<td>Working</td>
<td>-0.0545</td>
<td>-0.7300</td>
<td>Minimum distance from district center</td>
<td>0.0000</td>
<td>0.5783</td>
</tr>
<tr>
<td>Mandatory activity</td>
<td>0.2117</td>
<td>2.2344 **</td>
<td>Housework sharing</td>
<td>0.1182</td>
<td>1.7584*</td>
<td>Infrastructures within 400m</td>
<td>-0.0069</td>
<td>-0.8052</td>
</tr>
<tr>
<td>Restraint activity</td>
<td>0.1268</td>
<td>2.0811 **</td>
<td>Number of family</td>
<td>0.0322</td>
<td>2.3999**</td>
<td>Accompanied</td>
<td>0.4592</td>
<td>4.8497 ***</td>
</tr>
<tr>
<td>Activity preference</td>
<td>-0.0212</td>
<td>-0.7280</td>
<td>Age</td>
<td>0.0243</td>
<td>0.9952</td>
<td>Age</td>
<td>0.0223</td>
<td>1.7982 *</td>
</tr>
<tr>
<td>Trip chaining</td>
<td>-0.1697</td>
<td>-2.7388***</td>
<td>Disposable income</td>
<td>-0.0522</td>
<td>-2.7869***</td>
<td>Accompanied</td>
<td>0.4592</td>
<td>4.8497 ***</td>
</tr>
<tr>
<td>Journey per day</td>
<td>0.0409</td>
<td>1.5612</td>
<td>Ability to walk</td>
<td>0.0223</td>
<td>1.7982 *</td>
<td>Accompanied</td>
<td>0.4592</td>
<td>4.8497 ***</td>
</tr>
<tr>
<td>Accompanied</td>
<td>0.0655</td>
<td>1.1891</td>
<td>IADL</td>
<td>-0.0339</td>
<td>-1.3955</td>
<td>IADL</td>
<td>0.0655</td>
<td>1.1891</td>
</tr>
<tr>
<td>Private motor vehicles</td>
<td>0.0655</td>
<td>1.1891</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Data analysis

Multiple regression analysis

- Dividing data by trip purposes (mandatory, restraint, and discretionary) and trip composition (chaining or single trip) will provide better goodness of fit ($R^2$)
- For more restraint activities, the models have higher $R^2$, built environment variables are more crucial when analyzing chaining trips.

<table>
<thead>
<tr>
<th>Data division model</th>
<th>R</th>
<th>R Square</th>
<th>ANOVA df1 df2 F Sig. F</th>
<th>Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Single trip &amp;</td>
<td>0.848</td>
<td>.719</td>
<td>6 15 6.397 .002</td>
<td>Sig. Predictors: Activity-travel time, Private motor vehicle, Age, IADL, Local population density, Distance from district centre</td>
</tr>
<tr>
<td>Mandatory</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Single trip &amp;</td>
<td>0.744</td>
<td>.554</td>
<td>3 113 46.801 .000</td>
<td>Sig. Predictors: Activity-travel time, Accompanied, Married</td>
</tr>
<tr>
<td>Restrictive</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Single trip &amp;</td>
<td>0.61</td>
<td>.373</td>
<td>6 233 23.053 .000</td>
<td>Sig. Predictors: Activity-travel time, Private motor vehicle, Journey per day Disposable income, Number of Family, high educational level</td>
</tr>
<tr>
<td>Discretionary</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Trip chaining &amp;</td>
<td>0.861</td>
<td>.741</td>
<td>7 24 9.826 .000</td>
<td>Sig. Predictors: Indoor nonsleeping time, Journey per day, Private Motorized, Married, Housework sharing, Local population density, Distance from district centre</td>
</tr>
<tr>
<td>Mandatory</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Trip chaining &amp;</td>
<td>0.729</td>
<td>.532</td>
<td>5 51 11.589 .000</td>
<td>Sig. Predictors: Activity-travel time, Indoor nonsleeping time, Accompanied, Number of Family, Local population density</td>
</tr>
<tr>
<td>Restrictive</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Trip chaining &amp;</td>
<td>0.672</td>
<td>.451</td>
<td>6 85 11.639 .000</td>
<td>Sig. Predictors: Activity-travel time, Indoor nonsleeping time, Accompanied, Age, ability to walk, Local population density</td>
</tr>
<tr>
<td>Discretionary</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Data analysis

Potential action space (For 3 main activities)

- Mandatory activities appear to have higher TTRs but shorter activity duration, in contrast to the other two.
- Private motorized vehicles provide higher mobility, but for mandatory activities, bus or taxi might be alternatives to travel further.
- 400 metres for walking for all kinds of activities are reasonable.

<table>
<thead>
<tr>
<th>Activity by mode</th>
<th>Predicted TTR</th>
<th>Expected activity duration (Minutes)</th>
<th>Travel time (Minutes)</th>
<th>Potential Travel Distance (one-way)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mandatory</td>
<td>0.2757</td>
<td>46.56</td>
<td>16.56</td>
<td>2.42</td>
</tr>
<tr>
<td>Mandatory by private motorized</td>
<td>0.2517</td>
<td>37.78</td>
<td>13.34</td>
<td>2.66</td>
</tr>
<tr>
<td>Mandatory on foot</td>
<td>0.2928</td>
<td>26.00</td>
<td>14.03</td>
<td>0.37</td>
</tr>
<tr>
<td>Mandatory by others</td>
<td>0.3070</td>
<td>86.92</td>
<td>25.99</td>
<td>4.12</td>
</tr>
<tr>
<td>Restraint</td>
<td>0.2350</td>
<td>109.89</td>
<td>17.12</td>
<td>2.34</td>
</tr>
<tr>
<td>Restraint by private motorized</td>
<td>0.2574</td>
<td>122.85</td>
<td>17.35</td>
<td>3.53</td>
</tr>
<tr>
<td>Restraint on foot</td>
<td>0.2217</td>
<td>78.24</td>
<td>15.74</td>
<td>0.42</td>
</tr>
<tr>
<td>Restraint by others</td>
<td>0.1704</td>
<td>138.67</td>
<td>19.87</td>
<td>2.29</td>
</tr>
<tr>
<td>Discretionary</td>
<td>0.1700</td>
<td>103.63</td>
<td>17.50</td>
<td>1.76</td>
</tr>
<tr>
<td>Discretionary by private motorized</td>
<td>0.1685</td>
<td>108.94</td>
<td>17.27</td>
<td>3.54</td>
</tr>
<tr>
<td>Discretionary on foot</td>
<td>0.1719</td>
<td>97.99</td>
<td>16.91</td>
<td>0.45</td>
</tr>
<tr>
<td>Discretionary by others</td>
<td>0.1672</td>
<td>111.06</td>
<td>20.20</td>
<td>2.11</td>
</tr>
</tbody>
</table>

Note: Distance in kilometres
Data analysis

Quality of Life evaluation

- Motor vehicles improve accessibility and reduce gap within urban area
- Urban-rural gap of person-based accessibility of public transport is huge
- Pattern of walking accessibility is similar to motor vehicles, but with larger gap
Data analysis

Quality of Life evaluation

- Motor vehicles improve accessibility and reduce gap within urban area
- Pattern of walking accessibility is similar to motor vehicles, but with larger gap
Conclusion & recommendation

Conclusion:
• Activity-based approach can observe travel behaviour in sophisticated detail and support transport planning.
• Activity-travel patterns, individual background and built environment have various impacts on TTRs, regression model show activity type and scheduling are far more important than others.
• Motor vehicles help maintain accessibility of the older, public transport and walking potential action space are smaller, causing elderly living outside downtown show significantly lower accessibility.

Recommendation:
• Database development is time and money consuming but worth investment.
• Time perception of the elderly could cause research bias, fuzzy theory would help in further research.
• Walking potential action space application is more practical. Potential action space of discretionary activity in downtown, urban and suburban area can provide reference for specific facility planning.
Reference


Thank you for attention!