A Goal-Driven Perspective on Choice Behaviour and Choice Models

Joffre Swait

14th International Conference on Travel Behaviour Research

Windsor, UK

July 19-23, 2015
Please reference as ...

3½ years ago I moved to Sydney ...

• ... to take a job at UTS:CenSoC.
• Who was I then?
  • 57 years old
  • (Re)Married 3 years before
  • No children in the home
  • Career: in & out of consulting & academia, moved a lot, at the University of Alberta immediately preceding

• Questions for urban and transport planners:
  1. Where would I live in Sydney?
  2. Would I rent or buy? Would I live in a detached home or a unit?
  3. Would I own a car?
  4. Would I use transit?
Here are the answers ...

1. Heart of the North Shore
2. Rent a unit
3. No car
4. Transit only
Why did I make these choices?

• I don’t like apartments.
• I’m paying very high rent.
• I’ve owned cars everywhere I’ve lived for the last 40 years.
• Since my school boy years, I’ve not used transit regularly.

It would be helpful to understand the why of my move and what goals I had.
3½ years ago I moved to Sydney ...

• ... to inherit the kingdom [GOAL 1].
• BUT WOULD I ACTUALLY INHERIT?
  • Many uncertainties surrounded the situation!
• I needed to be prepared to leave Australia if things didn’t work out.
  • Minimize costs of “returning to base” [Goal 2.1]
    • negotiate contract appropriately
    • rent, not own; locate near public transit
• Make leaving Australia easy and quick [Goal 3.1]
  • not buy an automobile for the first time in 40 years
  • rent, not own; locate near public transit
Understanding my actions (choices) is much easier ... 

• ... if you know my motivations (GOALS) and concerns (GOALS & CONSTRAINTS).
Outline

• Individual goals & motivations matter to decision makers
  • So they should matter to modelers & policy-makers.
• Can we incorporate goals into models of behavior?
Would you like pudding, sir? Our menu ...
Well, it depends on what you’re trying to accomplish, doesn’t it?
Eat healthily

Indulge myself

Comfort myself w/ familiar foods

Eat healthily

Indulge myself

Comfort myself w/ familiar foods
Goals are metrics of success: they enable us to judge how well our needs & desires are met by different products & services.
Do I pursue one or the other, or both?
What is my decision strategy?

\[
\begin{align*}
\text{max} \{\text{Indulgence}\} & \quad \text{s.t.} \quad \{\text{Eat healthily}\} > \tau_E \\
\text{max} \{\text{Eat healthily}\} & \quad \text{s.t.} \quad \tau_{I1} > \{\text{Indulgence}\} > \tau_{I2}
\end{align*}
\]

[max] \{Indulgence\} 
and 
{Eat healthily}
Goals help us decide ... how to decide (Antecedent Volition).
Of course, your goal might be to manage exposure to potential allergens!

- Nuts
- Dairy
- Dairy & nuts
- Gluten
- Vegan
- Gluten
- Gluten
- Gluten
- Dairy

So … fruit salad or nothing for you!
• **Needs & desires** drive choice
• **Goals** indicate success in meeting needs & desires
• **Barriers** prevent the attainment of goals
Work commute
WHY do people commute as they do?

- Buses don’t always go where I need to go, and they are so inflexible!
- I work late at night & don’t feel safe using the metro.
- Being fit is important to me, so I walk to work.
- My spouse needs our car to get to work...
- There are no showers at work!
Goals and work commute mode choice

- Spatial and Temporal Flexibility
- Personal Wellness
- Partners both working to save for a larger home
- Social Acceptance
- Personal Safety
Goals matter because they guide & direct choice behavior ...
GOALS in decision making are ...

• **Metrics of success**
  • Attainment of needs

• **Multiple and simultaneous**
  • Mutually reinforce or conflict/compete
  • Hierarchical

• **Multiple and sequential**
  • Basis for intertemporal decision making
  • Basis for contextual adaptation
  • Basis for dyad/group decision making

• **Resource allocation mechanisms**
  • Cognitive and other resources
Consider one goal-based framing of a decision

Goal 1
Should I take the best?

Goal 2
Should I put all my eggs in one basket?
Suppose these two goals are simultaneously pursued but are not equally important.

\[ w_C \]

Goal 1
Exploitation

\[ 1 - w_C \]

Goal 2
Exploration

\{ Goal Balancing \}

Swait and Marley (2013), *Journal of Mathematical Psychology*
Choice modelers have been working with goals all along!

\[ \text{Max } \Psi = w_C \cdot \text{Exploitation}(p) + (1-w_C) \cdot \text{Exploration}(p) \]

s.t. constraints on \( p \)

\[ p_{jc} = \frac{\exp(r_c V_{jc})}{\sum_{i \in C} \exp(r_c V_{ic})}, \forall j \in C \]

\[ r_c = \frac{w_C}{(1-w_C)} \]

Swait and Marley (2013), *Journal of Mathematical Psychology*
Aside #1 for modellers ...

\[ p_{jc} = \frac{\exp(r_c V_{jc})}{\sum_{i \in C} \exp(r_c V_{ic})}, \forall j \in C \]

\[ r_c = w_c / (1 - w_c) \]

In “goal country” SCALE \( r_c \) is NOT about error distribution, but about RELATIVE GOAL IMPORTANCE.
Aside #2

\[
\text{[Max]} \quad \Psi = w_c \cdot \text{Exploitation}(p) + (1-w_c) \cdot \text{Exploration}(p)
\]

s.t. constraints on \( p \)

Stochasticity in choice is the outcome of multiple, simultaneous GOAL PURSUIT.
What might a goal-based approach to choice look like?
[Max ] $\Psi' = w_C \cdot \text{Exploitation}(p) + (1-w_C) \cdot \text{Adherence}(p/q)$

s.t. constraints on $p$

$$p_{jc} = \frac{\exp(r_C V_{jc} + \ln q_{jc})}{\sum_{i \in C} \exp(r_C V_{ic} + \ln q_{ic})}, \forall j \in C$$

$$r_C = w_C/(1-w_C)$$
Here’s an idea!

Maybe we can customize choice model representations to the specific motivations (goals) relevant to the domain/decision we’re modelling!
Swait & Marley (2013) suggest ...

Choice models based on specific combinations of motivations:

• Exploitation
• Exploration
• Targeting & adherence
• Regret
• Satisficing
How can we incorporate goals into models of choice?

• Ask people!
  • Self-reported goals
NEEDS & Desires

Goal Activation

- In Control
- High Mobility
- Personal Safety

Goal Assessment & Tradeoffs

Develop models that use goals as basis for segments or preference heterogeneity.
Do people screen alternatives (i.e., form choice sets) on the basis of their motivations for visiting the park?

Thiene, Swait and Scarpa (2015) “Choice set formation for outdoor destinations: the role of motivations and preference discrimination in site selection for the management of public expenditures on protected areas”, under 2nd review at JEEM.
Motivations for park visits & barriers to site visitation

Self-reported goals
- Relax
- Spend time with the family
- Acquire and/or improve skills
- Knowledge of the territory
- Contact with nature

Constraints
- Walking disability
- Health problems
- Small kids
- Lack of training
- Lack of technical skills
- Constraints due to other people
- Lack of free time
- Lack of money
CSF by Goal Constraints

CSF by Goal Recruitment
Self-reports

• Can be unreliable.
• And how do you forecast self-reports?
How can we incorporate goals into models of choice?

• Don’t ask people!
  • Infer (functional) goals from data

Simple Process Block Diagram

Goal Priority System

(Functional) Goal Attainment System
Behavioral Framework of Simultaneous Multiple Goal Pursuit

- Prior Goal Weighting
- Goal-specific Attribute Evaluation
- Goal Weight Adaptation?
- Choice
- Product Attributes
- Individual Characteristics
- Tendency to Adapt
Multiple Goal-Based Choice Model (MGBCM)

- Implements conceptual model of multiple & simultaneous goal pursuit
  - Prior goal-weighting
  - Goal weight adaptation
- Model nests latent class preference model
- Model does not use self-reported goals for estimation; reserved for validation
- Model system described in Li(2013) and
Data Collection

• Product category: P&S digital cameras
• Pilot survey
  • Generate self-report goal list
• Main model-building survey (DCE)
  • 1890 participants
  • # tasks: 8
  • Camera profiles: designed with 10 attributes
  • # alternatives=(2,4,8)
• (Out-of-sample) Validation survey (DCE)
  • 1002 participants
  • # tasks: 16
  • 10 real cameras, only price varied ±20% market average
  • # alternatives=(4,5,6)
Model selection

(a) Optimum Number of Goals for the Proposed Goal-Based Choice Model

<table>
<thead>
<tr>
<th>Model</th>
<th>k</th>
<th>LL</th>
<th>BIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-Latent-Goal Model</td>
<td>52</td>
<td>-19316</td>
<td>39132</td>
</tr>
<tr>
<td>3-Latent-Goal Model</td>
<td>84</td>
<td>-19036</td>
<td>38880</td>
</tr>
<tr>
<td>4-Latent-Goal Model</td>
<td>116</td>
<td>-18822</td>
<td>38761</td>
</tr>
<tr>
<td><strong>5-Latent-Goal Model</strong></td>
<td><strong>146</strong></td>
<td><strong>-18644</strong></td>
<td><strong>38693</strong></td>
</tr>
<tr>
<td>6-Latent-Goal Model</td>
<td>177</td>
<td>-18504</td>
<td>38712</td>
</tr>
</tbody>
</table>

(b) Optimum Number of Latent Classes for the Competing Utility-Based Choice Model

<table>
<thead>
<tr>
<th>Model</th>
<th>k</th>
<th>LL</th>
<th>BIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-Latent-Class Model</td>
<td>47</td>
<td>-19389</td>
<td>39230</td>
</tr>
<tr>
<td>3-Latent-Class Model</td>
<td>78</td>
<td>-19105</td>
<td>38961</td>
</tr>
<tr>
<td><strong>4-Latent-Class Model</strong></td>
<td><strong>109</strong></td>
<td><strong>-18904</strong></td>
<td><strong>38858</strong></td>
</tr>
<tr>
<td>5-Latent-Class Model$^a$</td>
<td>140</td>
<td>-18686</td>
<td>38720</td>
</tr>
<tr>
<td>6-Latent-Class Model</td>
<td>171</td>
<td>-18558</td>
<td>38762</td>
</tr>
</tbody>
</table>

**MGBBCM fits better in-sample**
But do latent constructs predict self-reports?

<table>
<thead>
<tr>
<th>Latent Goals</th>
<th>Self-reported Functional Goals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>keep up with new technology</td>
</tr>
<tr>
<td></td>
<td>have a camera</td>
</tr>
<tr>
<td></td>
<td>that is easy to carry</td>
</tr>
<tr>
<td></td>
<td>have a camera</td>
</tr>
<tr>
<td></td>
<td>that is easy to use</td>
</tr>
<tr>
<td></td>
<td>minimize spending on cameras</td>
</tr>
<tr>
<td></td>
<td>have a reliable/durable camera</td>
</tr>
<tr>
<td>LG1</td>
<td>⬅️</td>
</tr>
<tr>
<td>LG2</td>
<td>⬅️ ⬅️ ⬅️ ⬅️ ⬅️</td>
</tr>
<tr>
<td>LG3</td>
<td>⬅️</td>
</tr>
<tr>
<td>LG4</td>
<td>⬅️</td>
</tr>
<tr>
<td>LG5</td>
<td>⬅️ ⬅️ ⬅️</td>
</tr>
</tbody>
</table>
But do latent constructs predict self-reports?

Self-reported Functional Goals

- have a camera that is easy to carry
- have a camera that is easy to use
- take good quality pictures
- minimize spending on cameras
- have a reliable/durable camera

MGBCM constructs are strongly related (associated) to self-reported goals.

LCM (taste heterogeneity) has NO relationship to self-reports.
The acid test: out-of-sample validation

<table>
<thead>
<tr>
<th>Sample</th>
<th>Model</th>
<th>BIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimation</td>
<td>LCM</td>
<td>38,858</td>
</tr>
<tr>
<td></td>
<td>MGBCM</td>
<td>38,693</td>
</tr>
<tr>
<td>Validation</td>
<td>LCM</td>
<td>43613</td>
</tr>
<tr>
<td></td>
<td>MGBCM</td>
<td>41373</td>
</tr>
</tbody>
</table>

165 pt advantage for MGBCM

2240 pt advantage for MGBCM
The acid test: out-of-sample validation

<table>
<thead>
<tr>
<th>Sample</th>
<th>Model</th>
<th>BIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Validation</td>
<td>MGBCM</td>
<td>41373</td>
</tr>
</tbody>
</table>

Did the direct modelling of goals using the MGBCM capability of goal weight adaptation allow MUCH BETTER prediction performance?
Can latent goals also be detected in the screening (recruitment) of alternatives to form choice sets?

Goals & Choice Set Formation

**Objective:**
Measurement task to identify effect of goals on CSF.

**Method:**
*Availability design* (between 3 and 9 alternatives).

---

[Example of availability design in dessert choices with a table showing preferences and reasons for choices]
Statistical modeling

<table>
<thead>
<tr>
<th>Constructs</th>
<th>Best LL</th>
<th>AIC</th>
<th>BIC</th>
<th>Best LL</th>
<th>AIC</th>
<th>BIC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tourism</td>
<td></td>
<td></td>
<td>Desserts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>-39378.51</td>
<td>78889.01</td>
<td>79174.19</td>
<td>-34829.7</td>
<td>69811.48</td>
<td>70138.89</td>
</tr>
<tr>
<td>2</td>
<td>-38671.76</td>
<td>77549.52</td>
<td>77994.55</td>
<td>-34391.8</td>
<td>69017.65</td>
<td>69521.70</td>
</tr>
<tr>
<td>3</td>
<td>-38184.46</td>
<td>76648.92</td>
<td>77253.82</td>
<td>-34152.1</td>
<td>68620.28</td>
<td>69300.96</td>
</tr>
<tr>
<td>4</td>
<td>-37909.26</td>
<td>76172.51</td>
<td>76937.29</td>
<td>-33878.1</td>
<td>68154.21</td>
<td>69011.56</td>
</tr>
<tr>
<td>5</td>
<td>-37607.72</td>
<td>75792.71</td>
<td>76568.08</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Best solutions in **Bold**; non-stable solution *Italicised*
Goal-screening at the individual level

Desserts (ID 64)
Associations Between Constructs, Justifications and Goals for Desserts

self-reported goals

- maximise cost to benefit ratio
- enjoy a familiar taste
- avoid physical and mental repercussions
- indulge in the experience
- satisfy immediate desires

justification for elimination

- unhealthy/poison/teeth/artificial/fructose/sweetener/sugar/cholesterol
- tea/coffee
- meal/filling
- keen/appeal/interest/tempting
- rich/sweet

latent construct

- fat
- heavy
- flavour
- health/nutritional/digest
- self-reported goals: G1, G2, G3, G4

- filling
- tea/coffee
- meal/filling
- rich/sweet
- health/nutritional/digest
- self-reported goals: G1, G2, G3, G4
Associations Between Constructs, Justifications and Goals for Desserts

Model constructs reflect self-reported goals.

Model constructs are semantically different.
Let’s gather these various threads ...

Could richer, theoretically based behavioral process representation lead to better forecasting performance?

- Lucas (1976) – model parameters embody history of process
  - If models can’t adapt to structural changes, they’re going to give biased forecasts.
- Putting “behavior” into models must, however, be theory driven and must allow for adaptation over contexts and time.
  - Economics, psychology, consumer behavior, sociology, transport, geography, organizational behavior, marketing, IT (online)
- GOALS may be a key element in accomplishing this for us!
GOALS...

• ... are the reason for people CHOOSING or NOT CHOOSING alternatives.
  • Define whether (or the extent to which) success is attained
  • Can also represent high-level constraints
• ... help people define Antecedent Volitions.
  • Decision strategies
  • Divide-and-conquer: decomposition of multi-dimensional decisions
  • Choice set formation
• ... help people allocate resources in ways that help them become successful in their lives.
GOALS can be modelled directly

• High-level motivations can be used to formulate statistical models from first principles.
  • Goal-balancing: Swait and Marley (2013)

• Functional goals can be detected and quantified in panel stated preference data
  • Functional, evaluative goals
  • Screening goals

• Will this happen in panel revealed preference data?
  • Data collection challenges: methods, panels, length
GOALS & Decisions over time ...

• Modeling decision sequences over time has always been & remains a big challenge.

• Perhaps if we understood goal activation, goal set adoption and goal pursuit, we’d be able to more accurately predict choices over time?
  • Goal dynamics should be our focus.

• Important area for future research in goal-based choice modeling!
The Institute for Choice ...

• ... is very interested in pursuing goal-based choice modeling research.
  • Work commute mode choice: Swait, Bliemer, Axhausen
    • Motivations for Commuting Plans (choice sets)
  • Neighborhood selection: Bruch and Swait
    • Pursuit of in-group presence in neighborhood screening and evaluation
  • Recreational site selection: Thiene, Swait, Scarpa
    • Motivations for site visitation

• We’d love to hear from you!
Thank you!