Discrete Choice Experiments (DCEs): Theory and Applications

Seminar RIVM, Bilthoven, the Netherlands
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Erasmus Choice Modelling Centre (www.erim.eur.nl/ecmc)
Content

- What is a Discrete Choice Experiment (DCE)?
- How to conduct a DCE?
- How are DCEs applied and reported in health care?
- Future research
Content

- What is a Discrete Choice Experiment (DCE)?
- How to conduct a DCE?
- How are DCEs applied and reported in health care?
- Future research
DCEs: What are they?

- Quantitative method to measure benefit/preferences
- Origins in mathematical psychology
- Main practice in marketing, environmental, transport economics
DCEs – What are they?

- Introduced in health care early 1990s
- as an economic technique to measure benefit beyond health outcomes.

DCE – Attribute based survey

- DCE is an attribute based survey (economic technique)

A DCE typically consists of:

- numerous respondents
- being asked to complete a number of choice tasks
<table>
<thead>
<tr>
<th></th>
<th>Program 1</th>
<th>Program 2</th>
<th>No screening</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deaths prostate cancer</td>
<td>18 out of 1000</td>
<td>25 out of 1000</td>
<td>35 out of 1000</td>
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<tr>
<td>Freq blood test</td>
<td>every 3 years</td>
<td>every 4 years</td>
<td>n.a.</td>
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<tr>
<td>Risk unnecessary biopsy</td>
<td>800 out of 1000</td>
<td>400 out of 1000</td>
<td>n.a.</td>
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<tr>
<td>Risk unnecessary treatment</td>
<td>500 out of 1000</td>
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<tr>
<td>Out-of-pocket costs annually</td>
<td>€ 50</td>
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<td>I prefer:</td>
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DCE – advantage

- Reasonably straightforward task (ordinal instead of cardinal)
- Closely resembles a real world decision
- Many output possibilities (OR, WTP, MRS, utility scores, probs)
Research question (some examples)

- What is the willingness to pay to receive a more comprehensive prenatal testing?
- How willing are patients to wait for a treatment in a hospital they prefer?
- How much risk reduction is required to consider treatment X as acceptable?
- How to implement an intervention in an effective way?
- How do individuals weigh the harms and benefits of treatment X?
- How is screening participation affected by the type of screening test?
- What outcomes are important to patients with long term conditions?
- Which uptake can be expected for vaccination against disease X?
- What do the people in this room value about their jobs?
Content

- What is a Discrete Choice Experiment (DCE)?
- How to conduct a DCE?
- How are DCEs applied and reported in health care?
- Future research

Note: this part contains several slides that are based on the course slides of “Bliemer & Rose. 2011. Course in Stated Choice Methods, Maastricht, the Netherlands” (i.e. slides 13-15, 17, 20, 27, 28, 32 and 34; agreement was received).
Discrete choice experiment process

Determining, what:
1 Alternatives
2 Attributes
3 Attribute levels
4 Utility function
5 Model
6 Statistical design
7 Number choice tasks

pre-experimental design decisions

experimental design
combi of attribute levels

questionnaire

results:
OR, MRS, utility scores, WTP, probabilities, ….

data

data analysis

\[ U_{in} = V(X_{in}, \beta) + \varepsilon_{in} \]

Task 1 out of 16

respondents

Erasmus MC
Discrete choice experiment process

Determining, what:

1. Alternatives
2. Attributes
3. Attribute levels
4. Utility function
5. Model
6. Statistical design
7. Number choice tasks

Pre-experimental design decisions

→ Decisions before we get to the DCE design

For more details, see e.g. Hensher DA, Rose JM, Greene WH. Applied choice analysis: a primer. Cambridge: Cambridge University Press, 2005.
## Pre-experimental design decisions

### 1. What and how many alternatives?

<table>
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<th>Program B</th>
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<td>Protection against cervical cancer</td>
<td>70%</td>
<td>90%</td>
<td>0%</td>
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<tr>
<td>Protection duration</td>
<td>Lifetime</td>
<td>6 years</td>
<td>n.a.</td>
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<tr>
<td>Serious side effects</td>
<td>very small</td>
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Which vaccination program do you prefer? □ A □ B □ None

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Which vaccination program do you prefer?

- □ A
- □ B
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Which vaccination program do you prefer?

- □ A
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Pre-experimental design decisions

2. What and how many attributes?
   Driven by research question

   → Literature, focus groups, expert interviews crucial!

Number of attributes
   too many?
      Increased error variance
      Lexicographic behaviour

Always pre-test and pilot your survey!!
3. What and how many attribute levels?

Driven by research question

- e.g. Do individuals prefer every year, every 2 years or every 5 years screening?
  - to test for (non-)linearity, at least 3 levels needed
## Pre-experimental design decisions

4. What will the utility functions of the model look like?

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Pre-experimental design decisions

4. What will the utility functions of the model look like?

Write out the utility functions you expect to estimate:

\[ V_{\text{program A}} = \beta_0 + \beta_1 \text{Effect} + \beta_2 \text{Duration}_25y + \beta_3 \text{Duration}_\text{lifetime} \]
\[ + \beta_4 \text{Serious} + \beta_5 \text{Mild} + \beta_6 \text{Age}_12y + \beta_7 \text{Age}_14y \]

\[ V_{\text{program B}} = \beta_8 + \beta_1 \text{Effect} + \beta_2 \text{Duration}_25y + \beta_3 \text{Duration}_\text{lifetime} \]
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\[ V_{\text{No vaccination}} = 0 \]

→ to have an overview of:
- how many parameters has to be estimated
- which attributes are linear/categorical and/or alternative specific
Pre-experimental design decisions

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→ to have an overview of:
- how many parameters has to be estimated
- which attributes are linear/categorical and/or alternative specific
Pre-experimental design decisions

5. What model will most likely to be estimated after data collection?
Model specification

- Restricted substitution pattern
  - Fixed variance
    - Preference heterogeneity
      - mixed logit
      - latent class model
    - No preference heterogeneity
      - heteroscedastic logit
  - Flexible variance
    - Preference heterogeneity
      - generalised MNL
    - No preference heterogeneity
  - More general substitution pattern
    - Fixed variance
      - Preference heterogeneity
        - mixed nested logit
      - No preference heterogeneity
    - Flexible variance
      - Preference heterogeneity
        - correlated multinomial probit
      - No preference heterogeneity

Source: De Bekker-Grob et al. 2012. DCEs in health economics: a review of the literature. Health Econ
Model specification

Restricted substitution pattern

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More general substitution pattern

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Source: De Bekker-Grob et al. 2012. DCEs in health economics: a review of the literature. Health Econ
6. What statistical properties should the design display?
There are a lot of different designs one can choose

- Full factorial designs
- Non-full factorial designs
  - Orthogonal designs
  - Efficient designs
  - Bayesian efficient designs
  ....

Depends on preferred statistical properties, the information available, and the preferred size of the design.

### Pre-experimental design decisions

7. How many choice tasks should be included in the design?

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
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**Respondent perspective**

**Statistical design perspective**
7. How many choice tasks should be included in the design?

- Respondent perspective

- Burden and fatigue
- Learning effect
Pre-experimental design decisions

7. How many choice tasks should be included in the design?

Statistical design perspective

Each parameter requires a degree of freedom:

- alternative specific constant(s)
- main effects
- interaction effects
etc.

That’s why writing out the expected utility functions is important!
Discrete choice experiment process

Determining, what:
1 Alternatives
2 Attributes
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4 Utility function
5 Model
6 Statistical design
7 Number choice tasks

pre-experimental design decisions

Experimental design
combi of attribute levels
Full factorial designs

- Designs in which all possible choice situations are included.

For example:
Assuming an unlabelled design (2 options per choice set)

- 2 attributes with 3 levels $\rightarrow 3^2 = 9$ alternatives (choice situations)
  $\rightarrow 9*((9-1)/2) = 36$ choice sets

- 3 attributes with 3 levels $\rightarrow 3^3 = 27$ alternatives (choice situations)
  $\rightarrow 27*((27-1)/2) = 351$ choice sets

- 4 attributes with 3 levels $\rightarrow 3^4 = 81$ (choice situations)
  $\rightarrow 81*((81-1)/2) = 3,240$ choice sets
Full factorial designs

How to reduce the number of choice situations?

- Reduce the number of attributes
- Reduce the number of attribute levels
- Create a non-full factorial design …
Non-full factorial designs

Designs that use a subset of choice situations

**Advantage**
Reduction of the number of choice situations shown to each respondent

**Disadvantage**
Because only a fraction of the choice situations is used, not all effects can be measured

**Note**
Remember there is a lower bound on the number of choice situations.
# Non-full factorial designs

<table>
<thead>
<tr>
<th></th>
<th>Orthogonal designs</th>
<th>Optimal orthogonal designs</th>
<th>(Bayesian) efficient designs</th>
<th>Optimal choice prob designs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Widely used</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ease of generation</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Efficiency of design</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Prior parameter info needed</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Model flexibility</td>
<td>-/+</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
</tbody>
</table>

Adapted from Bliemer & Rose. 2011. Course in Stated Choice Methods, Maastricht
Determining, what:

1. Alternatives
2. Attributes
3. Attribute levels
4. Utility function
5. Model
6. Statistical design
7. Number choice tasks

**pre-experimental design decisions**

**experimental design**

**questionnaire**

Always pre-test and pilot your survey!!
Discrete choice experiment process

Determining, what:
1 Alternatives
2 Attributes
3 Attribute levels
4 Utility function
5 Model
6 Statistical design
7 Number choice tasks

Pre-experimental design decisions

Experimental design
combi of attribute levels

Questionnaire

Task 1 out of 16

- Paper & pencil, panel data, interviewer based,..
- Sample size *(for more information, see De Bekker-Grob et al. 2015. Sample size requirements for discrete choice experiments in health care: a practical guide. Patient.)*
Discrete choice experiment process

Determining, what:
1. Alternatives
2. Attributes
3. Attribute levels
4. Utility function
5. Model
6. Statistical design
7. Number choice tasks

\[ U_{\text{in}} = V(X_{\text{in}}, \beta) + \varepsilon_{\text{in}} \]

OR, MRS, utility scores, WTP, probabilities, …

Content

- What is a Discrete Choice Experiment (DCE)?
- How to conduct a DCE?
- How are DCEs applied and reported in health care?
- Future research
## Overview DCE practice (1)

<table>
<thead>
<tr>
<th>Country of origin</th>
<th>1990-2000(^1) (n=34)</th>
<th>2001-2008(^2) (n=114)</th>
<th>2009-2012(^3) (n=178)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UK</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>US</td>
<td>59</td>
<td>48</td>
<td>22</td>
</tr>
<tr>
<td>Australia</td>
<td>18</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td>Canada</td>
<td>3</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>Denmark</td>
<td>0</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Netherlands</td>
<td>0</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>Germany</td>
<td>0</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>11</td>
<td>25</td>
</tr>
</tbody>
</table>

**Systematic reviews:**

1. Ryan, Gerard. Appl Health Econ Health Policy. 2003
2. de Bekker-Grob, Ryan, Gerard. Health Econ. 2012
3. Clark, Determann, Petrou, Moro, de Bekker-Grob. PharmaEcon. 2014
## Overview DCE practice (2)

<table>
<thead>
<tr>
<th>Main study objective</th>
<th>1990-2000(^1) (n=34)</th>
<th>2001-2008(^2) (n=114)</th>
<th>2009-2012(^3) (n=178)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) Valuing experience factors</td>
<td>35%</td>
<td>35%</td>
<td>12%</td>
</tr>
<tr>
<td>(B) Valuing health outcomes</td>
<td>9%</td>
<td>7%</td>
<td>6%</td>
</tr>
<tr>
<td>(C) Trade-offs health outcomes &amp; experience factors</td>
<td>41%</td>
<td>33%</td>
<td>41%</td>
</tr>
<tr>
<td>(D) Utility weights within QALY framework</td>
<td>0%</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>(E) Job-choices</td>
<td>6%</td>
<td>4%</td>
<td>6%</td>
</tr>
<tr>
<td>(F) Developing priority setting frameworks</td>
<td>6%</td>
<td>5%</td>
<td>13%</td>
</tr>
<tr>
<td>(G) Health professional's preferences</td>
<td>3%</td>
<td>15%</td>
<td>12%</td>
</tr>
<tr>
<td>(H) Other</td>
<td>0%</td>
<td>4%</td>
<td>10%</td>
</tr>
</tbody>
</table>

Note * Percentages do not add up to 100% as several studies had more than one main objective
## Overview DCE practice (3)

<table>
<thead>
<tr>
<th></th>
<th>1990-2000 (n=34)</th>
<th>2001-2008 (n=114)</th>
<th>2009-2012 (n=178)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of attributes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-3</td>
<td>15 %</td>
<td>13 %</td>
<td>9 %</td>
</tr>
<tr>
<td>4-5</td>
<td>29 %</td>
<td>44 %</td>
<td>33 %</td>
</tr>
<tr>
<td>6</td>
<td>26 %</td>
<td>26 %</td>
<td>34 %</td>
</tr>
<tr>
<td>7-9</td>
<td>12 %</td>
<td>13 %</td>
<td>22 %</td>
</tr>
<tr>
<td>10</td>
<td>6 %</td>
<td>2 %</td>
<td>2 %</td>
</tr>
<tr>
<td>&gt;10</td>
<td>12 %</td>
<td>2 %</td>
<td>2 %</td>
</tr>
<tr>
<td><strong>Attributes covered</strong>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monetary measure</td>
<td>56 %</td>
<td>54 %</td>
<td>56 %</td>
</tr>
<tr>
<td>Time</td>
<td>74 %</td>
<td>51 %</td>
<td>66 %</td>
</tr>
<tr>
<td>Risk</td>
<td>35 %</td>
<td>31 %</td>
<td>57 %</td>
</tr>
<tr>
<td>Health status domain</td>
<td>56 %</td>
<td>54 %</td>
<td>61 %</td>
</tr>
<tr>
<td>Health care</td>
<td>82 %</td>
<td>69 %</td>
<td>72 %</td>
</tr>
<tr>
<td>Other</td>
<td>9 %</td>
<td>15 %</td>
<td>47 %</td>
</tr>
</tbody>
</table>

* Percentages do not add up to 100% as studies use many attributes
## Overview DCE practice (4)

<table>
<thead>
<tr>
<th>Number of choices per respondent</th>
<th>1990-2000 (n=34)</th>
<th>2001-2008 (n=114)</th>
<th>2009-2012 (n=178)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 or less choices</td>
<td>38%</td>
<td>39%</td>
<td>21%</td>
</tr>
<tr>
<td>9-16 choices</td>
<td>53%</td>
<td>38%</td>
<td>62%</td>
</tr>
<tr>
<td>More than 16 choices</td>
<td>6%</td>
<td>18%</td>
<td>15%</td>
</tr>
<tr>
<td>Not clearly reported</td>
<td>3%</td>
<td>4%</td>
<td>4%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Administration of survey*</th>
<th>1990-2000 (n=34)</th>
<th>2001-2008 (n=114)</th>
<th>2009-2012 (n=178)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-complete questionnaire</td>
<td>79%</td>
<td>67%</td>
<td>48%</td>
</tr>
<tr>
<td>Interviewer administered</td>
<td>9%</td>
<td>19%</td>
<td>17%</td>
</tr>
<tr>
<td>Computerised interview</td>
<td>9%</td>
<td>11%</td>
<td>40%</td>
</tr>
<tr>
<td>Not reported</td>
<td>3%</td>
<td>8%</td>
<td>3%</td>
</tr>
</tbody>
</table>

* Percentages do not add up to 100% as studies use multiple methods.
<table>
<thead>
<tr>
<th>Design source</th>
<th>1990-2000 (n=34)</th>
<th>2001-2008 (n=114)</th>
<th>2009-2012 (n=178)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software package</td>
<td>56%</td>
<td>52%</td>
<td>53%</td>
</tr>
<tr>
<td>SPEED</td>
<td>38%</td>
<td>19%</td>
<td>4%</td>
</tr>
<tr>
<td>SPSS</td>
<td>6%</td>
<td>12%</td>
<td>6%</td>
</tr>
<tr>
<td>SAS</td>
<td>0%</td>
<td>12%</td>
<td>21%</td>
</tr>
<tr>
<td>SAWTOOTH</td>
<td>6%</td>
<td>4%</td>
<td>13%</td>
</tr>
<tr>
<td>Other</td>
<td>6%</td>
<td>0%</td>
<td>8%</td>
</tr>
<tr>
<td>No further details</td>
<td>0%</td>
<td>4%</td>
<td>4%</td>
</tr>
<tr>
<td>Catalogue</td>
<td>6%</td>
<td>5%</td>
<td>10%</td>
</tr>
<tr>
<td>Website</td>
<td>0%</td>
<td>3%</td>
<td>5%</td>
</tr>
<tr>
<td>Expert</td>
<td>12%</td>
<td>4%</td>
<td>6%</td>
</tr>
<tr>
<td>Not clearly reported</td>
<td>26%</td>
<td>37%</td>
<td>26%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Method to create choice sets*</th>
<th>1990-2000 (n=34)</th>
<th>2001-2008 (n=114)</th>
<th>2009-2012 (n=178)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orthogonal rays</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single profiles (i.e. binary choices)</td>
<td>9%</td>
<td>11%</td>
<td>1%</td>
</tr>
<tr>
<td>Random pairing</td>
<td>53%</td>
<td>17%</td>
<td>10%</td>
</tr>
<tr>
<td>Pairing with constant comparator</td>
<td>18%</td>
<td>20%</td>
<td>3%</td>
</tr>
<tr>
<td>Foldover - random pairing</td>
<td>0%</td>
<td>1%</td>
<td>2%</td>
</tr>
<tr>
<td>Foldover</td>
<td>0%</td>
<td>10%</td>
<td>17%</td>
</tr>
<tr>
<td>D-efficiency</td>
<td>0%</td>
<td>12%</td>
<td>30%</td>
</tr>
<tr>
<td>Other (pragmatically chosen)</td>
<td>12%</td>
<td>2%</td>
<td>5%</td>
</tr>
<tr>
<td>Not clearly reported</td>
<td>9%</td>
<td>28%</td>
<td>26%</td>
</tr>
<tr>
<td>Other</td>
<td>N / A</td>
<td>N / A</td>
<td>10%</td>
</tr>
</tbody>
</table>
# Overview DCE practice (6)

<table>
<thead>
<tr>
<th>Estimation procedure*</th>
<th>1990-2000 (n=34)</th>
<th>2001-2008 (n=114)</th>
<th>2009-2012 (n=178)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Probit</td>
<td>18</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Random effects probit</td>
<td>53</td>
<td>41</td>
<td>10</td>
</tr>
<tr>
<td>Logit</td>
<td>3</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>Random effects logit</td>
<td>3</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>MNL</td>
<td>18</td>
<td>22</td>
<td>43</td>
</tr>
<tr>
<td>Nested logit (NL)</td>
<td>0</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Mixed logit (MXL)</td>
<td>3</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Latent class (LCM)</td>
<td>0</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Other</td>
<td>3</td>
<td>4</td>
<td>17</td>
</tr>
<tr>
<td>Not clearly reported</td>
<td>6</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

Note: * Totals do not add up to 100% as some studies use multiple estimation procedures
## Overview DCE practice (7)

<table>
<thead>
<tr>
<th>Validity test*</th>
<th>1990-2000 (n=34)</th>
<th>2001-2008 (n=114)</th>
<th>2009-2012 (n=178)</th>
</tr>
</thead>
<tbody>
<tr>
<td>External</td>
<td>0%</td>
<td>1%</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Internal:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Theoretical</td>
<td>65%</td>
<td>56%</td>
<td>60%</td>
</tr>
<tr>
<td>Non-satiation</td>
<td>44%</td>
<td>49%</td>
<td>21%</td>
</tr>
<tr>
<td>Transitivity</td>
<td>9%</td>
<td>4%</td>
<td>1%</td>
</tr>
<tr>
<td>Sen’s expansion and contraction</td>
<td>0%</td>
<td>2%</td>
<td>1%</td>
</tr>
<tr>
<td>Compensatory decision making</td>
<td>35%</td>
<td>32%</td>
<td>14%</td>
</tr>
</tbody>
</table>

Note: * Totals do not add up to 100% as some studies use multiple validity tests
Conclusions DCE applications

- DCEs commonly used instrument in health care
- Covering wide range of policy questions
- Broad range of health-care systems
- A shift towards
  - Statistically more efficient designs
  - Flexible econometric models
- External validity tests are limited
Content

- What is a Discrete Choice Experiment (DCE)?
- How to conduct a DCE?
- How are DCEs applied and reported in health care?
- Future research
Future research

Among others:

- External validity
- Incorporating DCE results into a decision-making framework
- Complexity (e.g. level overlap, colour coding, presenting risk)
- Eye-tracking
- Advanced choice models and utility functions
- Random regret minimization models
- DCE for QALY estimation
- …
QUESTIONS?

e.debekker@erasusmc.nl

See also:
Erasmus Choice Modelling Centre
(www.erim.eur.nl/ecmc)