Conjoint analysis or Stated preference analysis is a statistical technique that originated in mathematical psychology. The presentation explains the principle, using a simple example. It shows how to calculate the part-worth utilities and how to derive the relative preferences from individual attributes from there. A full factorial and a fractional factorial design is used. An Excel template for this example is available from the author.
Today it is used in many of the social sciences and applied sciences including

- Marketing,
- Product management,
- Operations research.

Conjoint Analysis
Basic Principle

Keywords
conjoint analysis, stated preference analysis, linear regression, product management, marketing, part-worth, utilities, relative preference, statistics, analytic hierarchy process, AHP

Conjoint Analysis
Basic Principle

Buying a smart phone, MP3 player...

a

32 GB, off the shelf

Attribute 1: Memory

b

64 GB, one week delivery

Attribute 2: Delivery

Your Preference

The preference for a combination of (conjoint) attributes will reveal the “part-worth” of individual attributes.

Attribute 1: Memory
Attribute 2: Delivery
Buying a smart phone, MP3 player…

a

32 GB, off the shelf

Higher emphasis on short delivery time.

b

64 GB, one week delivery

Higher emphasis on large memory size

Conjoint Analysis
Basic Principle

The preference for a combination of (conjoint) attributes will reveal the “part-worth” of individual attributes.

Conjoint Analysis
Basic Principle

Part-worth utilities of individual attributes are calculated based on the ranking of a defined set of combinations of attribute values.
Conjoint Analysis
Basic Principle

Attribute values are coded with -1 and +1

Example
Buying a smart phone

Attribute 1: Color
Attribute 2: Memory
Attribute 2: Delivery

Buying a smart phone, MP3 player...

Attributes:
- Color: green, red
- Memory: 16 MB, 64 MB
- Delivery: 1 day, 1 week

Models:
1. Green, 16 MB, 1 week
2. Red, 16 MB, 1 week
3. Green, 64 MB, 1 week
4. Red, 64 MB, 1 week
5. Green, 16 MB, 1 day
6. Red, 16 MB, 1 day
7. Green, 64 MB, 1 day
8. Red, 64 MB, 1 day

"Conjoint" Attributes

Sequence
1. Green, 16 MB, 1 week
2. Red, 16 MB, 1 week
3. Green, 64 MB, 1 week
4. Red, 64 MB, 1 week
5. Green, 16 MB, 1 day
6. Red, 16 MB, 1 day
7. Green, 64 MB, 1 day
8. Red, 64 MB, 1 day

Color:
-1 -1 -1 -1 -1 -1 -1 -1
Memory:
1 -1 1 1 -1 -1 1 1
Delivery:
-1 1 1 1 1 1 1 1

Conjoint Analysis
Basic Principle

Example
Buying a smart phone

Attribute values are coded with -1 and +1

Attribute 1: Color
Attribute 2: Memory
Attribute 2: Delivery
Conjoint Analysis

**Basic Principle**

- **Full factorial Design**
  - Design Matrix
  - \( k \) attributes: \( 2^k \) possible combinations

**Graphical Representation of Combinations**

- \( X_1 \): Color = (+1,-1)
- \( X_2 \): Memory = (+1,-1)
- \( X_3 \): Delivery = (+1,-1)
Conjoint Analysis

Basic Principle

Linear model function with part-worth utilities

Ranking = part-worth of attribute 1 * attribute 1 level + part-worth of attribute 2 * attribute 2 level + part-worth of attribute 3 * attribute 3 level + baseline preference

\[ Y = \beta_{\text{color}} X_1 + \beta_{\text{memory}} X_2 + \beta_{\text{delivery}} X_3 + \mu \]

Conjoint Analysis

Basic Principle

Linear Model Function

The system of linear equations can be solved with linear regression

X1: Color = (+1,-1)
X2: Memory = (+1,-1)
X3: Delivery = (+1,-1)
Conjoint Analysis 7.7.2010 Gp
Conjoint Analysis

Basic Principle

Calculating Part-worth Utilities

\[ \beta_{\text{Color}} = -0.5 \]

Graphical Representation of Combinations

\[ \beta_{\text{Memory}} = -2 \]

\[ \beta_{\text{Color}} = \frac{1}{4} \left( 16 - 20 \right) + 2 = -0.5 \]

\[ \beta_{\text{Memory}} = \frac{1}{4} \left( 10 - 26 \right) + 2 = -2 \]
Conjoint Analysis

Basic Principle

Graphical Representation of Combinations

Calculating Part-worth Utilities

\[ \beta_{\text{Color}} = -0.5 \]
\[ \beta_{\text{Memory}} = -2 \]
\[ \beta_{\text{Delivery}} = -1 \]

Main effect X3

\[ \beta_{\text{Del}} = \frac{1}{4} \left( [14 - 22] + 2 \right) = -1 \]

Part-worth utilities

\[ \beta_{\text{Color}} = -0.5 \]
\[ \beta_{\text{Mem}} = -2 \]
\[ \beta_{\text{Del}} = -1 \]
Conjoint Analysis
Basic Principle

Actual ranking and description with linear model function

Y = 4.5 - 0.5 \( \beta_{\text{Color}} \) - 2 \( \beta_{\text{Memory}} \) - 1 \( \beta_{\text{Delivery}} \)

\( \beta_{\text{Color}} = -0.5 \)
\( \beta_{\text{Memory}} = -2 \)
\( \beta_{\text{Delivery}} = -1 \)
Conjoint Analysis

Basic Principle

Variations for $X_i = \pm 1$

$\pm 1 \cdot \beta_{\text{Del}} = \pm 2 = 4$

$\pm 1 \cdot \beta_{\text{Mem}} = \pm 0.5 = 1$

$\pm 1 \cdot \beta_{\text{Col}} = \pm 1 = 2$

Conjoint Analysis & Analytic Hierarchy Process (AHP)

Combinations

$2^k$ Combinations

$k=4$: 16 possible combinations

Comparisons

$k^2 - k \over 2$ Comparisons

$k=4$: 6 pair-wise comparisons

Conjoint Analysis

Attributes

Part-worth Utilities

Levels

Ranking

Calculating relative preferences

Criteria, Sub-criteria - comparison

Weights: Principal Eigenvector

Ratio Scale, relative Scale

Evaluation of Alternatives

Conjoint Analysis

Basic Principle

Delivery

29%

Memory

57%

Color

14%
Conjoint Analysis

Basic Principle

Fractional Design

Graphical Representation

Fractional design

$2^{3-1}$
Conjoint Analysis

Basic Principle

Fractional factorial design $2^p$

Graphical Representation

Calculating Part-worth Utilities

$\beta_{\text{Color}} = -0.5$

$\beta_{\text{Memory}} = -2$

Main effect $X_1$

$\frac{1}{2} \left[ (7+1)-(4+6) \right] \div 2 = -0.5$

Main effect $X_2$

$\frac{1}{2} \left[ (4+1)-(7+6) \right] \div 2 = -2$
Conjoint Analysis
Basic Principle

Fractional Design
Graphical Representation

Calculating Part-worth Utilities
\[ \beta_{\text{Color}} = -0.5 \]
\[ \beta_{\text{Memory}} = -2 \]
\[ \beta_{\text{Delivery}} = -1 \]

Conjoint Analysis
Basic Principle

Fractional Design
Using a fractional factorial design the number of attribute combinations can be reduced.
Conjoint Analysis
Basic Principle

Simple conjoint analysis can be done with linear regression, but more sophisticated statistical models and solutions are available.