



# Session 3: Conjoint Design (Part 2)

Fall 2018

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# What Have We Learned so Far?

# What Have We Learned Last Time?

Green invented  
Conjoint  
Based on the  
Random Utility  
Theory

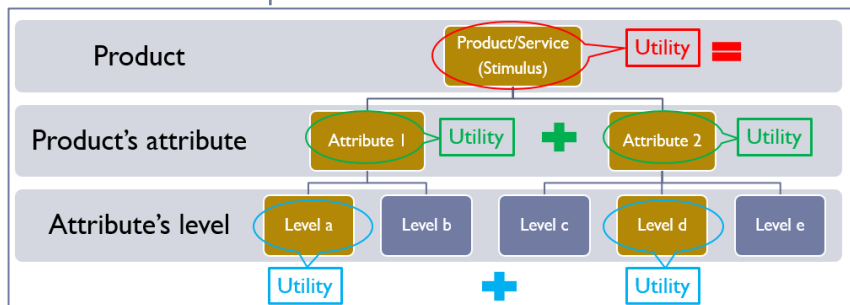
Customers  
choose the  
stimulus that  
maximizes their  
utility

$$P(i|C) = P[U_i > U_j], \text{ for all } j \in C$$

Noise

$$U_i = \beta_1 x_{i1} + \beta_2 x_{i2} + \dots + \beta_k x_{ik} + \varepsilon_i$$

Utility for product  $i$       Pathworth      Attribute level



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Customers  
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**maximizes their  
utility**

## 7 steps of conjoint analysis

### Conjoint Design

1 Determine the type of study  
• e.g. rating or choice-based

2 Identify the relevant attributes  
• Which and how many?  
• Example

3 Specify the attributes' levels  
• Which and how many?  
• Example

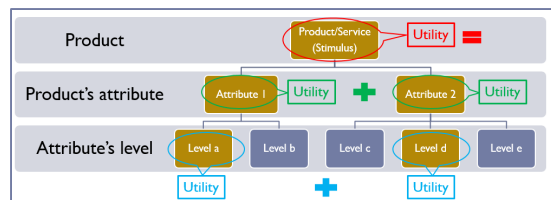
4 Design questionnaire  
• Which products to include?

### Conjoint Analysis

5 Collect data from respondents  
• Which channel, format and layout?

6 Estimate part-worths  
• Evaluate the attributes' levels

7 Design market simulators  
• What if scenarios in hypothetical markets



Direct  
questionnaires  
don't force  
**Trade-offs**

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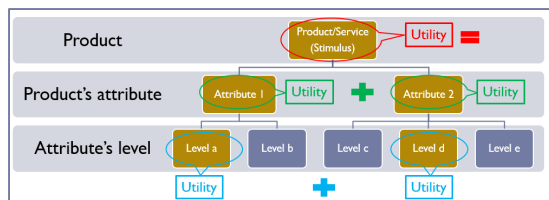
**7 steps of  
conjoint analysis**

Choose  
attributes  
and levels  
**together with  
the industry  
experts!**

**Advantages of  
CBC** include  
realism, no-  
choice, share  
calculation, no  
scaling  
problem and  
again...

**Max. 6  
attributes and  
2-4 levels  
(linear?  
# observations,  
same across  
attributes)**

Direct  
questionnaires  
don't force  
**Trade-offs**



# Key Aspects for a Good Design

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## STEP 1. How many stimuli to include?

- ▶ How many choice sets?
- ▶ How many stimuli per choice sets?

## STEP 2. Which stimuli to include?

- ▶ Level balance
- ▶ Orthogonality

## STEP 3. How to combine them in choice sets?

- ▶ Level overlap
- ▶ Utility balance

# How Many Stimuli to Include?

STEP 1 IN BUILDING YOUR CONJOINT DESIGN

# How Many Stimuli to Include?

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- ▶ How many possible combinations of attributes' levels does our design contain?
  - ▶ It depends on the number of attributes we selected
  - ▶ As well as on the number of levels of these attributes

$$\text{\# combinations} = 2^k \times 3^l \times 4^m \times 5^n \times \dots$$

With:

- ▶  $k$  = number of attributes with 2 levels
- ▶  $l$  = number of attributes with 3 levels
- ▶  $m$  = number of attributes with 4 levels
- ▶  $n$  = number of attributes with 5 levels (try to avoid !)



# How Many Stimuli to Include?

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- ▶ Whether we can include all possible stimuli in the questionnaire depends on:
  - ▶ Length of the questionnaire (i.e. number of choice sets)
  - ▶ Number of alternatives per choice set
- ▶ If we include all combinations
  - ▶ **Full factorial design**
  - ▶ E.g. 3 attributes, each with 2 levels → 8 stimuli
- ▶ If we only include a fraction of them
  - ▶ **Fractional factorial design**
  - ▶ E.g. 7 attributes, each with 2 levels → 128 stimuli but we include 24 only

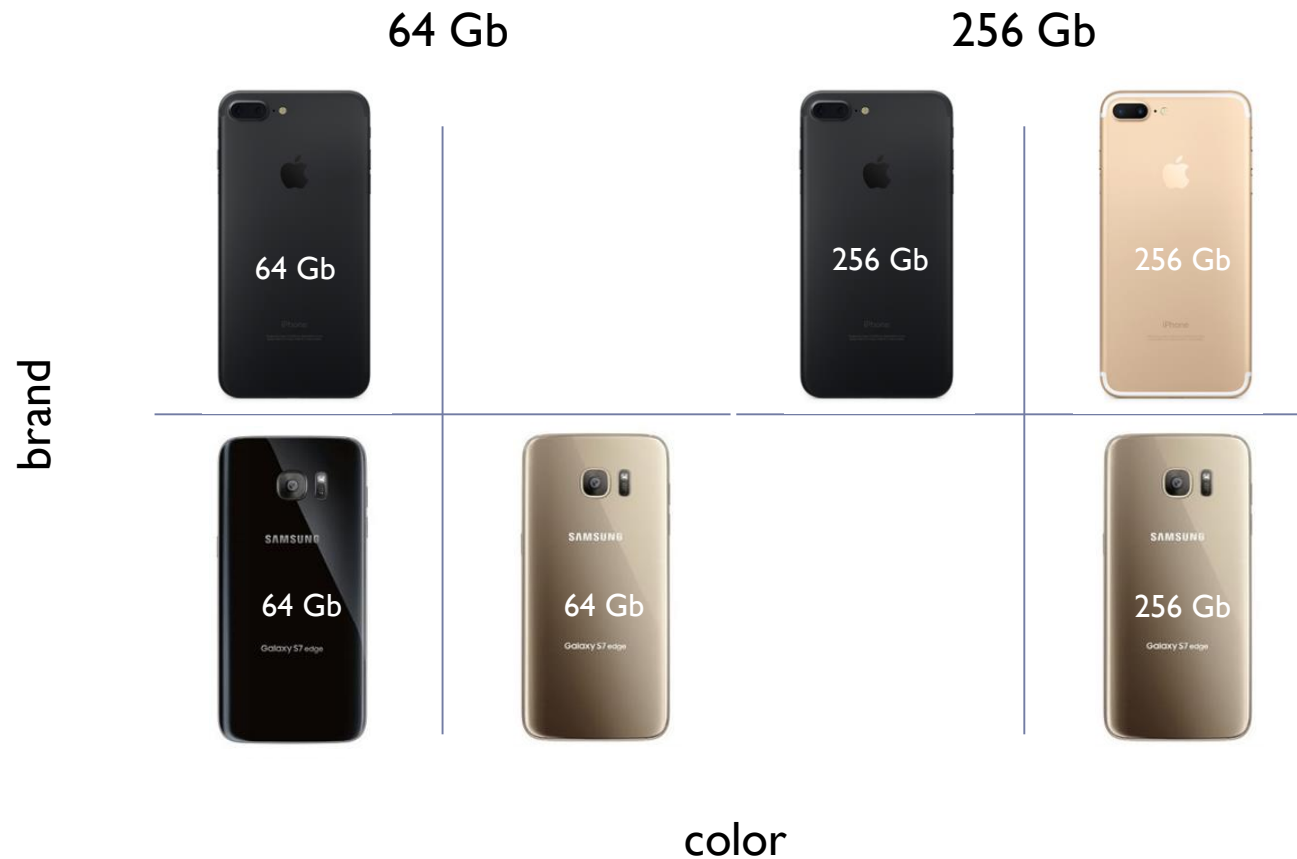
# Full Factorial Design: 2 x 2 x 2 levels

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# Fractional Factorial Design

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# Length of the Questionnaire

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- ▶ Advantages of large questionnaire:
  - ▶ More observations per respondent (more reliable estimates)
  - ▶ Increase in quality, as respondents learn how to answer
- ▶ Disadvantage of large questionnaire:
  - ▶ Decrease in quality, as respondents get fatigued or bored
- ▶ Rule of thumb: no more than 20 choice sets, 12 will often do (Johnson and Orme, 1996)
- ▶ Depends on number of parameters to be estimated (more levels means more parameters hence more data needed)

# How Many Alternatives per Choice Set?

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Delux Hamburger Value meal: \$3.99	Chicken Sandwich Value meal: \$3.59	Fish Sandwich Value meal: \$3.99
<ul style="list-style-type: none"><li>- Delux hamburger</li><li>- Medium fries</li><li>- Medium drink</li></ul>	<ul style="list-style-type: none"><li>- Chicken Sandwich</li><li>- Medium fries</li><li>- Medium drink</li></ul>	<ul style="list-style-type: none"><li>- Fish Sandwich</li><li>- Medium fries</li><li>- Medium drink</li></ul>

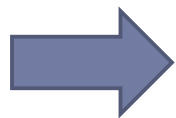
# How Many Alternatives per Choice Set?

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- ▶ Usually 2 to 4 alternatives per choice set
- ▶ The more alternatives, the more information the respondents have to process
  - ▶ E.g. 3 stimuli (in one choice set) characterized by 4 attributes each
    - ▶ = 12 bits of information to process
  - ▶ E.g. 2 stimuli (in one choice set) characterized by 6 attributes each
    - ▶ = 12 bits of information
- ➔ *The larger the number of attributes, the lower the number of alternatives a respondent can handle.*
- ▶ Do not exceed 18-20 bits of information
  - ▶ E.g. 3 alternatives with 6 attributes

# How Many Alternatives per Choice Set?

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How many bits of information does this choice set contain?

# Which Stimuli to Include?

STEP 2 IN BUILDING YOUR CONJOINT DESIGN



# And now?

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- ▶ We have now decided how many choice sets we want and how many alternatives per choice set.
- ▶ Therefore, we know how many stimuli we need to select.
- ▶ But... how do we decide which ones to select?

# Which Stimuli to Include?

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# Which Stimuli to Include?

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# Which Stimuli to Include?

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- ▶ Many possible designs
  - ▶ E.g. the number of ways to select 20 stimuli out of 128 is  $1.2 \times 10^{23}$
- ▶ Optimal design?
  - ▶ Provides as much info as possible about respondent's preferences for given number of tasks
  - ▶ Minimizes standard errors of part-worth estimates

➔ *optimality criteria for a good design*

# Optimality Criteria for Design

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- ▶ Conditions for good choice design (Huber & Zwerina 1996)

- ▶ Level balance

*Which stimuli to include?*

- ▶ Levels of an attribute occur with equal frequency

- ▶ Orthogonality

- ▶ Levels of any two attributes occur independently

# Level Balance and Orthogonality

## ► Level balance:

- Levels of an attribute occur with equal frequency



# Level Balance and Orthogonality

## ► Level balance:

- Levels of an attribute occur with equal frequency



# Level Balance and Orthogonality

## ▶ Example: Smart Phone

- ▶ Attribute 1: color
  - ▶ Level 1: white
  - ▶ Level 2: black
- ▶ Attribute 2: Memory
  - ▶ Level 1: 32-bit
  - ▶ Level 2: 64-bit

Second questionnaire/design:

Number of occurrences of each level

	white	black	<b>TOTAL</b>
32-b	8	4	<b>12</b>
64-b	4	2	<b>6</b>
<b>TOTAL</b>	<b>12</b>	<b>6</b>	<b>18</b>

*Balanced?*

First questionnaire/design:

Number of occurrences of each level

	white	black	<b>TOTAL</b>
32-b	6	3	<b>9</b>
64-b	3	6	<b>9</b>
<b>TOTAL</b>	<b>9</b>	<b>9</b>	<b>18</b>

*Balanced?*

Third questionnaire/design:

Number of occurrences of each level

	white	black	<b>TOTAL</b>
32-b	5	5	<b>10</b>
64-b	5	5	<b>10</b>
<b>TOTAL</b>	<b>10</b>	<b>10</b>	<b>20</b>

*Balanced?*



# Level Balance and Orthogonality

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- ▶ Level balance:

- ▶ Levels of an attribute occur with equal frequency

- ▶ Orthogonality:

- ▶ Levels of any two attributes occur independently
  - ▶ Rate of occurrence for any combination of levels = rate of occurrence of first level x rate of occurrence of second level
  - ▶ Quick check: rows (and columns) are proportional to each other

# Level Balance and Orthogonality

## ▶ Example: Smart Phone

- ▶ Attribute 1: color
  - ▶ Level 1: white
  - ▶ Level 2: black
- ▶ Attribute 2: Memory
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*Orthogonal?*

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*Orthogonal?*

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64-b	5	5	<b>10</b>
<b>TOTAL</b>	<b>10</b>	<b>10</b>	<b>20</b>

*Orthogonal?*

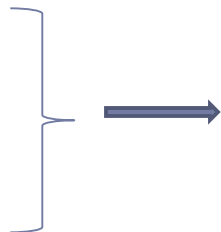
# Level Balance and Orthogonality

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- ▶ Not possible to achieve level balance and orthogonality for all numbers of stimuli
  - ▶ Example above: not possible for 18 stimuli
- ▶ Necessary condition:
  - ▶ 1. Number of stimuli should be divisible by the number of levels for any attribute (example above: 2)
  - ▶ 2. Number of stimuli should be divisible by the product of the number of levels for any pair of attributes (example above:  $2 \times 2 = 4$ )
- ▶ Example: 2 Attributes with 2 levels and 1 attribute with 3 levels:

multiple of

- ▶ 2 and 3
- ▶  $2 \times 2 = 4$
- ▶  $2 \times 3 = 6$



e.g. 24 stimuli would allow to satisfy  
both balance and orthogonality

➔ We can go for e.g. 12 choice sets of 2 stimuli each, 8 choice sets of 3 stimuli, ...

# Level Balance and Orthogonality

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- ▶ What to do if balanced and orthogonal design cannot be found?  
(e.g. large number of stimuli needed, exclusion of unrealistic stimuli)
- ▶ Ultimate objective is to obtain small standard errors → minimize D-error measure ( $\approx$  average variance)  $\Leftrightarrow$  maximize D-efficiency
- ▶ Level balance and orthogonality are tools to achieve this → tradeoff
- ▶ Design with neither balance nor orthogonality may have higher D- efficiency than design with exactly one of these two properties!

# How to Combine Stimuli in Choice Sets?

STEP 3 IN BUILDING YOUR CONJOINT DESIGN

# Optimality Criteria for Design

---

## ▶ Conditions for good choice design (Huber & Zwerina 1996)

### ▶ Level balance

*Which stimuli to include?*

- ▶ Levels of an attribute occur with equal frequency

### ▶ Orthogonality

- ▶ Levels of any two attributes occur independently

### ▶ Minimal level overlap

- ▶ Alternatives within choice set do not share same attribute levels

### ▶ Utility balance

- ▶ Difficult choices, i.e., (almost) equally attractive alternatives

*How to combine stimuli in choice sets?*

# Minimum Level Overlap

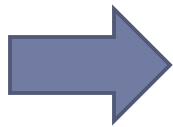
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## Stimulus 1

- ▶ 5 x zoom
- ▶ 10 megapixels
- ▶ 3 inches

## Stimulus 2

- ▶ 3 x zoom
- ▶ 6 megapixels
- ▶ 2 inches



Level Overlap for this choice set ?

# Minimum Level Overlap

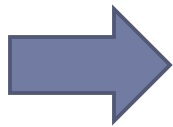
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Level Overlap for this choice set ?



# Minimum Level Overlap

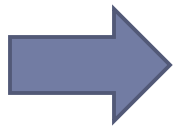
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## Stimulus 1

- ▶ 5 x zoom
- ▶ 10 megapixels
- ▶ 3 inches

## Stimulus 2

- ▶ 3 x zoom
- ▶ 10 megapixels
- ▶ 3 inches



Level Overlap for this choice set ?

# Minimum Level Overlap

- ▶ Different from no level overlap
- ▶ Level overlap will always occur if the choice sets contain more stimuli than levels exist per attribute
- ▶ Some level overlap is often recommended
  - ▶ It allows the estimation of interaction effects (e.g. brand and price)

Choice set 1:



None of them



Choice set 2:



None of them



# Utility Balance?



CAMPER/RV

## Malibu Dream Airstream

Malibu



ENTIRE HOUSE

## Stunning All Bamboo House on Pristine Valley edge





# Utility Balance?

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**Hotel Chez Maman in  
South Senegal**



**House with private swimming pool  
in South Spain**

# Utility Balance?

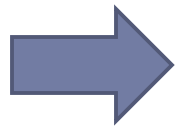
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## Stimulus 1

- ▶ 5 x zoom
- ▶ 10 megapixels
- ▶ 3 inches

## Stimulus 2

- ▶ 3 x zoom
- ▶ 6 megapixels
- ▶ 2 inches



Utility Balance?

# Utility Balance?

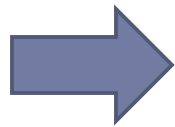
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## Stimulus 3

- ▶ 5 x zoom
- ▶ 6 megapixels
- ▶ 3 inches

## Stimulus 4

- ▶ 3 x zoom
- ▶ 10 megapixels
- ▶ 2 inches



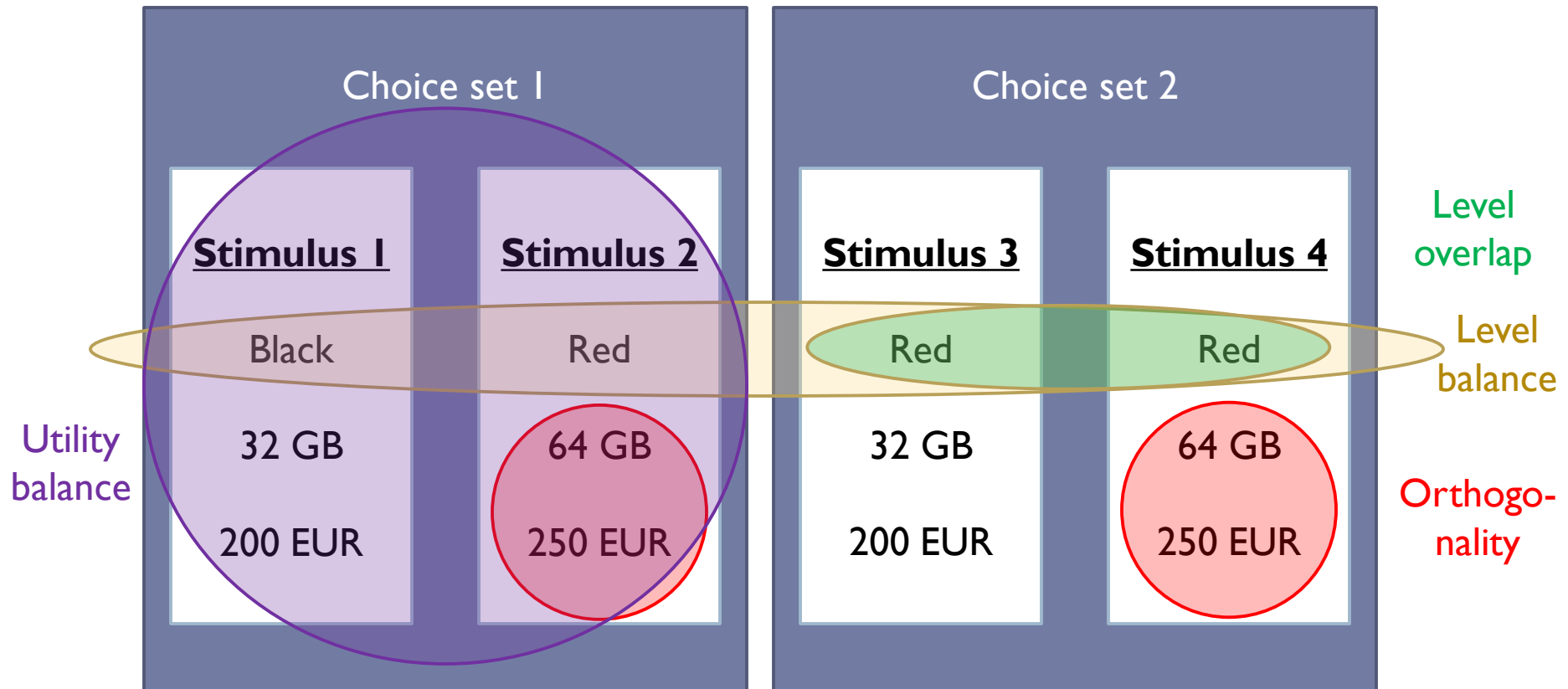
Utility Balance?

# Utility Balance

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- ▶ In general, utility balance is a very difficult criterion to satisfy
- ▶ Why?
  - ▶ To define difficult tradeoffs, we would need to know in advance how respondents will evaluate the different attribute levels
  - ▶ But this required input is actually what we want to learn
  - A classical chicken-egg problem
  - Sawtooth does not consider this criterion, but instead...

# Summary of the Four Criteria



A bad design!!!



# Randomized Designs

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- ▶ Sawtooth adds an extra element of complexity and offers to randomize the choice sets (tasks) that a respondent will receive
- ▶ Each respondent receives a unique questionnaire

# Randomized Designs

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Respondent 1

Choice set 1

Choice set 2

Choice set 3

...

Choice set 12

Respondent 2

Choice set 3

Choice set 10

Choice set 8

...

Choice set 2

Respondent 3

Choice set 6

Choice set 5

Choice set 7

...

Choice set 3



# Randomized Designs

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- ▶ Randomization reduces design efficiency (by 5 to 10%) but ...
- ▶ It reduces the impact of order effects and other context effects.
- ▶ It allows to explore main and interaction effects by allowing for some level overlap
- ▶ Select “Balanced overlap” (some level overlap is tolerated)
- ▶ Always add fixed holdout choice sets (tasks)

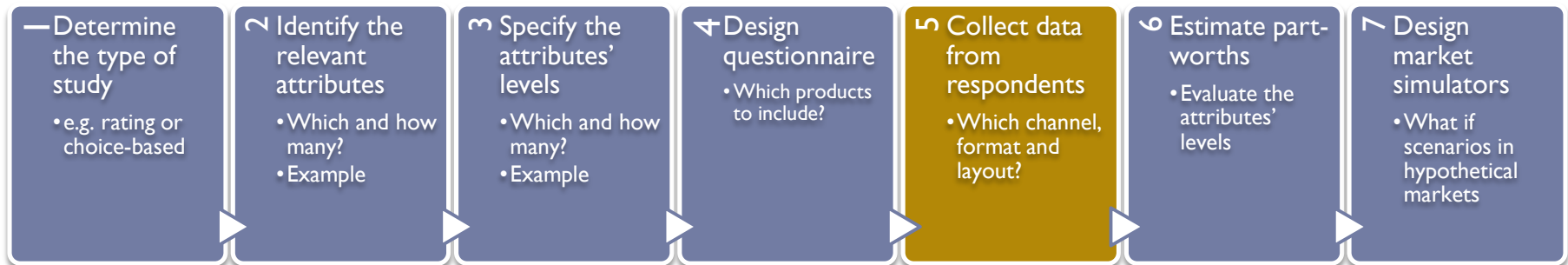
# Adding a No-Choice Option

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- ▶ Potential to include a “no-choice alternative”
  - ▶ None of the alternatives is good enough
  - ▶ I prefer my current product
- ⇒ Allows breakdown primary vs. secondary demand
- ⇒ Enhances ability to do market simulations

# Step 5: Collect Data from Respondents

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See example in Sawtooth:

[http://www.sawtoothsoftware.com/surveys/baseball/cgi-bin/ciweb.pl?hid\\_studynum=baseball&hid\\_pagenum=0](http://www.sawtoothsoftware.com/surveys/baseball/cgi-bin/ciweb.pl?hid_studynum=baseball&hid_pagenum=0)



**Hello:**

**You are invited to participate in our survey about the introduction of a new e-reader in the market. In this survey, approximately 50 people will be asked to complete a survey that asks questions about your preferences regarding several e-readers. It will take approximately 5 minutes to complete the questionnaire.**

**Your survey responses will be strictly confidential and data from this research will be reported only in the aggregate. Your information will be coded and will remain confidential. In this survey you have to choose between two e-readers in 20 choice sets.**

**Thank you very much for your time and support. Please start with the survey now by clicking on the Continue button below.**

.....



[Exit Survey >>](#)

Gender :

- ☐ Male
- ☐ Female

Evaluation License

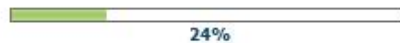
Educational Level:

- ☐ Bachelor
- ☐ Exchange
- ☐ Pre-Master
- ☐ Master

Evaluation License

Age :

Evaluation License



Exit Survey »

Step 2 of 20

From the choices presented, please select your most preferred choice.

Price	170€	100€	None
Storage Capacity	64GB	16GB	
Cloud	No	Yes	
Battery Life	60 days	30 days	
Camera	No	Yes	
Screen Size	8,9"	7"	
Wireless Connection	Wi-Fi	Wi-Fi & 4G	
	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>





Exit Survey »

Step 20 of 20

From the choices presented, please select your most preferred choice.

Price	280€	100€	None
Storage Capacity	16GB	16GB	
Cloud	No	No	
Battery Life	30 days	30 days	
Camera	No	No	
Screen Size	7"	7"	
Wireless Connection	Wi-Fi	Wi-Fi & 4G	

# Number of Respondents

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- ▶ Choice-based conjoint requires multiple respondents:
  - ▶ No guarantees, only guidelines
  - ▶ In practice, range from 150 to 1200 respondents (Orme 1998)
  - ▶ Minimum of 200 respondents per group/segment (Orme 1998)
  - ▶ Own experience: good results with 100 respondents, or multiple if you want to consider segments

Next Sessions:  
How to Analyze the CBC Data?