Measuring the Subjective User eXperience

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These handouts are subject to change prior to the tutorial. Please contact M.C. Kaptein for the latest version.

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Where innovation starts

About the presenter

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  - **BSc. Psychology (University of Tilburg – NL)**
  - **Msc. Economic psychology (University of Tilburg – NL)**
  - **Professional doctorate in Engineering: User System Interaction (Eindhoven University of Technology)**
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Aim of the tutorial

1. Get acquainted with the psychology terminology of designing and validating questionnaires
2. Have a thorough overview of the process of designing a questionnaire
3. Understand reliability and validity
4. Learn how to phrase items and design questionnaires
5. Learn about different sampling methods
6. Get acquainted with statistical techniques to validate questionnaires

Overview of this tutorial

1. The full design process
2. Questionnaire design
   1. Item construction
   2. Question wording
   3. Survey construction
   4. Pretesting
3. Theory of reliability and validity
4. Sampling
5. Statistical validation
   1. Correlations
   2. Cronbach's Alpha
   3. Factor analysis

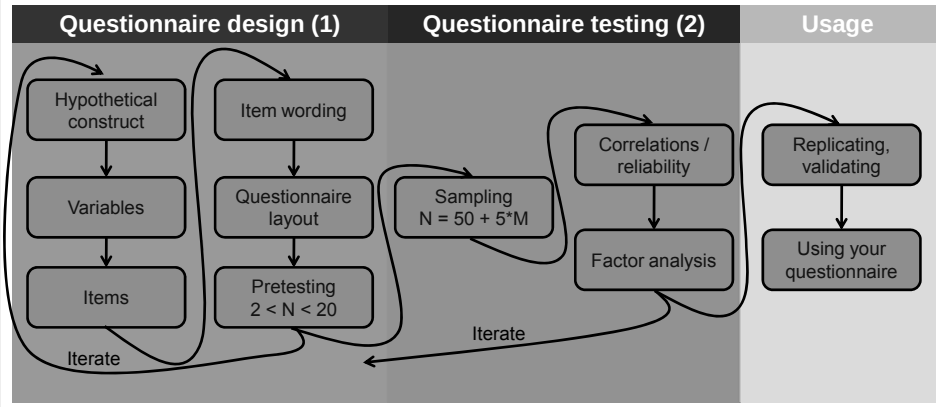
Hypothesis driven research

1. **Think through your *research questions* and objectives before you write questions**
2. **Prepare an *analysis plan* before you write questions**
3. **Ask yourself, in relation to points #1 and #2 above, if each question on your list is necessary? Even if the data would be 'interesting' it has to ultimately be used in analysis to make the cut!**

Theoretical background

Core concepts of questionnaire design

The design process



Hypothetical construct

Definition

A hypothetical construct is an identifier for a collection of attitudes or behaviors relating to underlying features or causes

Practical HCI examples

1. Usability
2. Social connectedness
3. Social presence
4. Fun
5. Engagement
6. System intelligence
7. Social intelligence
8. User intelligence (IQ)

Indentifying (latent) variables

Definition

A latent variable is one of the attitudes or behaviors which together form a hypothetical construct.

IQ examples

1. Language skill
2. Shape reckognition
3. Logic
4. Mathematical ability
5. Creativity

Operationalizing items

Definition

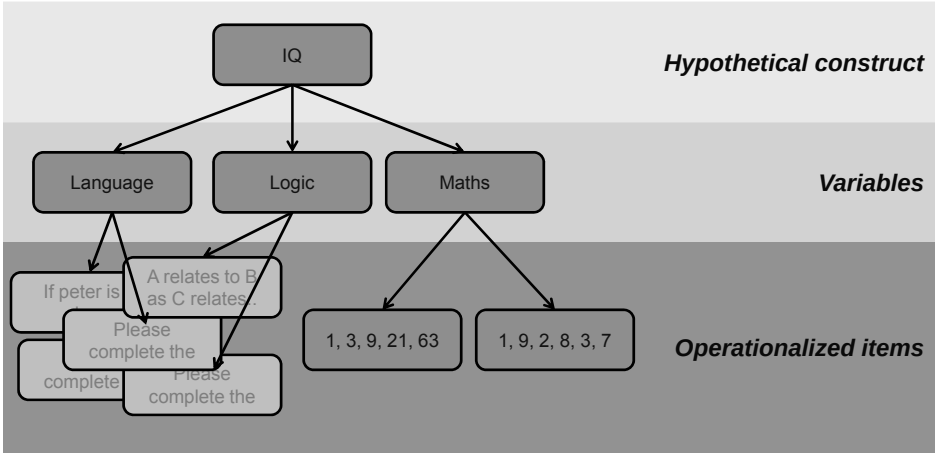
Operationalizing items relates to the translation of variables into items presented to the user.

Mathematical ability

1. 1,3,9,21,63, X_a
2. 1,9,2,8,3,7, X_b
3. 112, 2112, 122112, 11222112, X_c

$X_a = 198$; $X_b = 4$; $X_c = 21322112$

Overview



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Generating an item pool

1. **Determine the constructs you want to measure.**
2. **Find its variables**
   1. **In literature**
   2. **Trough qualitative sessions (focus groups)**
3. **Generate items**
   1. **From literature**
   2. **From qualitative session (brainstorms)**

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Designing your own

From constructing items to pretesting

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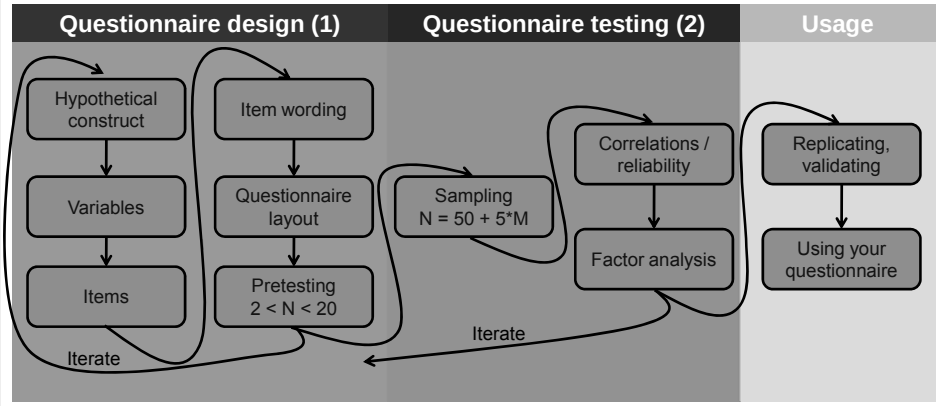
The design process



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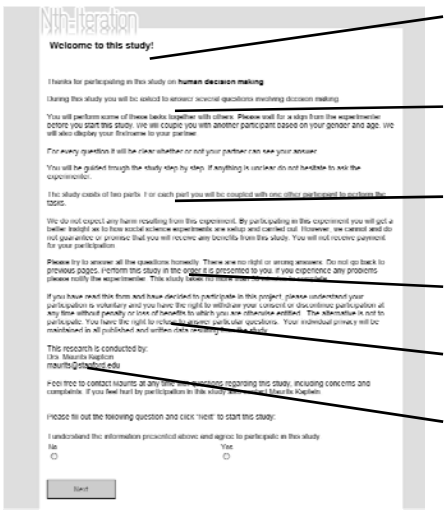
Main steps after generating your item pool

1. Write the introduction to your questionnaire
2. Evaluate the content of each item
3. Evaluate Inability or unwillingness to answer
4. Critically asses question wording
5. Determine the order of questions
6. Determine form and layout
7. Determine method of administring
8. Pretest your questionnaire
9. Iterate

Create the introduction

1. Fully inform participants about the research
   1. Who conducts the research?
   2. Why is it conducted?
   3. What is the aim?
   4. What is the length?
   5. What will the data be used for?
2. Obtain informed consent
3. Understand your target population
   1. Adapt your language
4. Put screening questions up front
   1. Use dummy questions when the topic is sensitive

Introduction example



Topic of the study

Process

Length

Data usage

Consent

Contact

Evaluate the contect of each question

1. **For each question, determine if the question is neccesary**
2. **Do not use double barreled question**
3. **Use familiar wording and spelling – adapt to the target group**
4. **Can the respondent remember?**
5. **Can the respondent articulate?**

Identify unwillingness or inability to answer

1. Minimize the effort required of participants
2. Is the context of the questions clear and appropriate
3. Make a request for information seem legitimate
4. In case of sensitive information:
   1. Place items at the end
   2. Preface with a 'common' statment
   3. Ask questions in 3rd person
   4. Hide questions in between others
   5. Provide response categories
   6. Use randomized techniques

Question wording

1. Define the issue in Who, What, When, Where, and what way (how)
2. Use ordinary words
3. Avoid ambiguous words
4. Avoid leading questions
5. Avoid implicit alternatives that are not expressed in the options
   1. Exclusive and exhaustive categories
6. Avoid implicit assumptions
7. Don't make respondents compute
8. Use both positive as well as negative statements

Bad examples 1: Double barreled questions

Bad	Better
Did you enjoy using our application, and would you buy it?	*Did you enjoy using our application?* *Would you buy this application?*

Bad examples 2: Leading questions

Bad	Better
Smart people generally do not watch a lot of television. Do you watch a lot of television?	*Do you watch television?* *How many hours a week do you spend watching television?*

Bad examples 3: People are bad at estimating

Bad	Better
Please specify how many minutes you spend each month using the internet: __ Min.	*How many hours a week, on average, do you use the following:* - *Email* - *Instant messaging* - *And so on…*

Bad examples 4: History

Bad	Better
What color socks were you wearing last Tuesday?	*Are you currently wearing socks?* *What color socks are you wearing today? (At least people can have a look)*

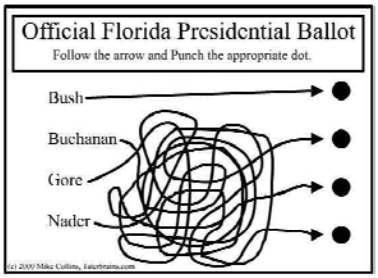
Bad examples 5: Jargon

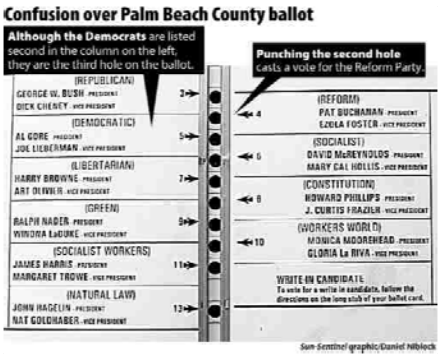
Bad	Better
Using the system made me feel more socially connected to my social network: *Agree _ _ _ _ _ _ Disagree*	*I felt closer to my friends by using the system:* Disagree | | | | Agree 0 | 0 | 0 | 0 | 0

Question order

1. **Make the opening questions simple**
2. **Qualifying questions should be in the beginning**
3. **End with identification questions**
4. **Put difficult questions at the end**
5. **From general to specific**
6. **From recent to old**
7. **Group items by topic**
8. **Make branching transparant**

Layout





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Layout checklist

Number all questions
Use large clear type, don't crowd
Make use of white space
Make answer categories clear
Consistent placement
Small to large
Group related topics
Don't split questions across pages
Distinguish directions from questions

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Layout checklist

1. Number all questions
2. Use large clear type, don't crowd
3. Make use of white space
4. Make answer categories clear
   1. Consistent placement
   2. Small to large
5. Group related topics
6. Don't split questions across pages
7. Distinguish directions from questions

Answer categories

What is your overall satisfaction with our product?

Not at all satisfied ○ ○ ○ ○ ○ Extremely satisfied

What is your overall satisfaction with our product?

Not at all satisfied	1	2	3	4	5	Extremely satisfied
	○	○	○	○	○	

What is your overall satisfaction with our product?

○ 1 ○ 2 ○ 3 ○ 4 ○ 5

What is your overall satisfaction with our product?

Not at all satisfied	Slightly satisfied	Moderately satisfied	Very satisfied	Extremely satisfied
○	○	○	○	○

- For likert type scales:
  - Even or odd?
  - Labeling?
  - Number of options?
  - "Don't know"?
  - Pictorials?

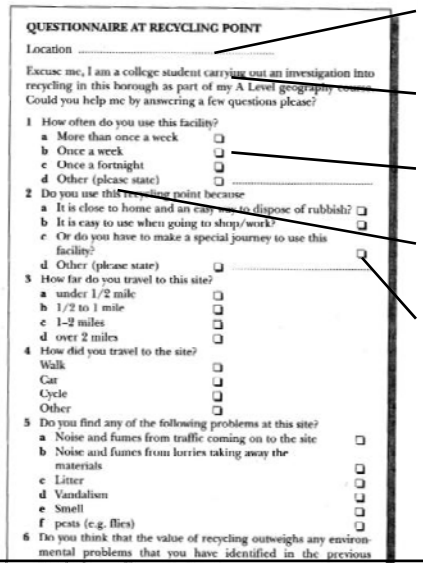
Methods of administering questionnaires

- Paper and pencil
- Personal interviews
- CAPI
- CATI
- CAWI
- Mobile phones

Pretesting your questionnaire

- Always pretest!
- Test all aspects of the questionnaire
- Test with the target group
- Test in the target medium
- Talk to your participants
- Re-test after modifications: Iterate
- Do not use the data from your pretest.

A nice questionnaire?



QUESTIONNAIRE AT RECYCLING POINT

Location .....

Excuse me, I am a college student carrying out an investigation into recycling in this borough as part of my A Level geography course. Could you help me by answering a few questions please?

1 How often do you use this facility?
- a More than once a week ☐
- b Once a week ☐
- c Once a fortnight ☐
- d Other (please state) ☐ .....

2 Do you use this recycling point because
- a It is close to home and an easy way to dispose of rubbish? ☐
- b It is easy to use when going to shop/work? ☐
- c Or do you have to make a special journey to use this facility? ☐
- d Other (please state) ☐ .....

3 How far do you travel to this site?
- a under 1/2 mile ☐
- b 1/2 to 1 mile ☐
- c 1–2 miles ☐
- d over 2 miles ☐

4 How did you travel to the site?
- Walk ☐
- Car ☐
- Cycle ☐
- Other ☐

5 Do you find any of the following problems at this site?
- a Noise and fumes from traffic coming on to the site ☐
- b Noise and fumes from lorries taking away the materials ☐
- c Litter ☐
- d Vandalism ☐
- e Smell ☐
- f pests (e.g. flies) ☐

6 Do you think that the value of recycling outweighs any environmental problems that you have identified in the previous

What to do with this?

Minimal intro

Logical categories?

No white space

Inconsistend placement

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Reliability and Validity

Evaluating a questionnaire

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Reliability

- **The degree to which measurements are consistent and do not contain errors**
- **Score of a participant = Score of the overall mean + effects of belonging to a group + *error***

- **Reliable: Measuring kilograms using a calibrated scale**
- **Unreliable: Measuring length using a flexible cord**

Common error: Regression towards the mean.

- **We perform an experiment to test our new interactive math education system:**
  - **We select the worst 20% of the a classroom – Their average math score is 3.2 out of 10.**
  - **We have them use our system for 1 week.**
  - **The average math score is now 4.5 out of 10.**

- **We perform an experiment to test our new dice throwing training programm.**
  - **We select people that throw a 1 or a 2. Their mean dice score is 1.5.**
  - **We have them train for a week**
  - **The average dice throwing score is now 3.5**

Validity

- **The extend to which a procedure measures what it intends to measure**
- **Does the IQ test really measure "*intelligence*"**

- **Valid: Measuring kilograms using a calibrated scale.**
- **Invalid: Measuring kilograms using a ruler.**

Construct and content validity

Construct validity:

Do our variables properly represent the hypothetical construct?

Is IQ really a combination of Math, Logic, and Language?

Content validity:

Do our items really measure the intended variable?

Is 1,3,9,21,63, .. A good reflection of mathematical ability?

Other types of validity

- **Internal validity: Does the experimental setup indeed manipulate what is intended?**
  - **No confounds?**
  - **No alternative interpretations?**
- **External validity: Can the findings be generalized?**
  - **Ecological validity**
  - **Temporal validity**
- **Face validity?**

Research methods and validity

- **Experiments**
  - **Great control over confounding variables**
  - **Out of context**
  - **High internal validity**
  - **Low external validity**
- **Correlational studies**
  - **Limited control over confounding variables**
  - **In context**
  - **Low internal validity**
  - **High external validity**

Recapp

- **We have covered:**
  - **From construct to item**
  - **Item generation**
  - **Questionnaire generation**
  - **Pretesting**
  - **Theoretical evaluation based on reliability and validity**

Measuring the Subjective User eXperience – part 2

A quantitative approach.

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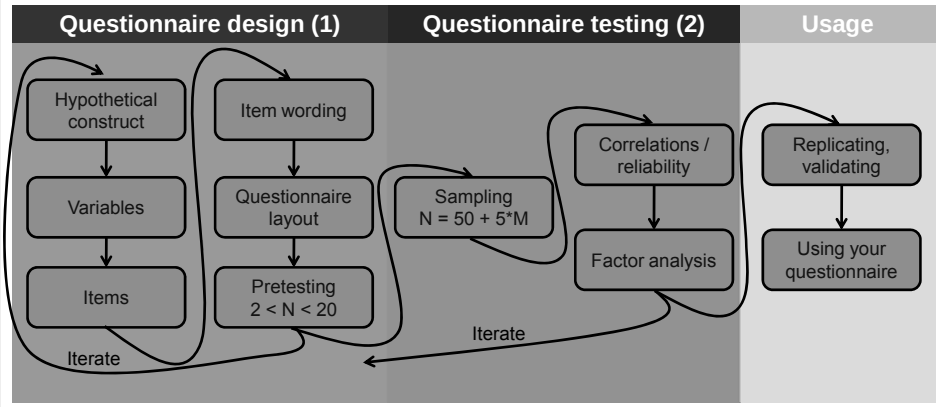
The design process



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Sampling respondents

So, who should fill out your questionnaire

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Designing your sample

- Define the population
- Determine the sampling frame
- Select a sampling technique
- Determine sample size
- Get those people

Sample size

- Sample size considerations:
  - Pretest 2 < N 20
  - Quantitative evaluation:
    - N > 300
    - N = 50 + 5*m
    - Rules of thumb

Different sampling techniques

- **Non probability sampling**
  - **Convenience sampling**
  - **Judgemental Sampling**
  - **Quota Sampling**
  - **Snowball Sampling**
- **Probability sampling**
  - **Simple Random Sampling**
  - **Systematic Sampling**
  - **Stratisfied Sampling**
  - **Cluster Sampling**

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Statistical analysis

We now have a lot of numbers – so what do we do with those

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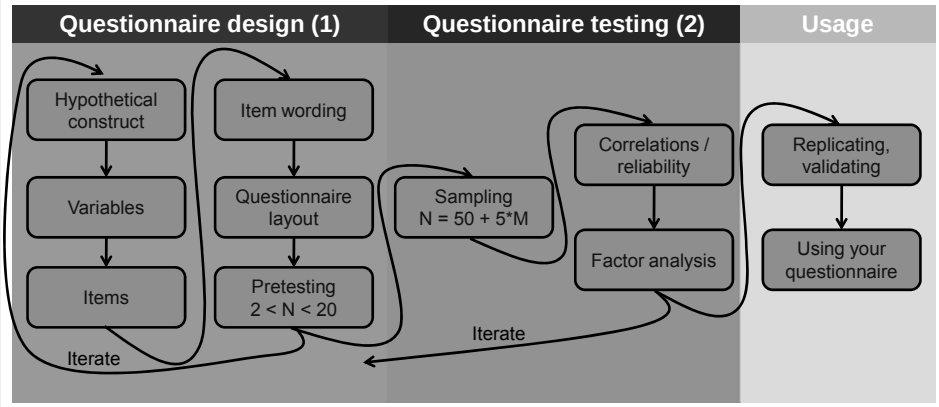
The design process



Correlation – Pearson product moment

- **The statistic is defined as the sum of the products of the standard scores of the two measures divided by the degrees of freedom. Based on a sample of paired data (X_i, Y_i), the sample Pearson correlation coefficient can be calculated as:**

$$r = \frac{1}{n-1}\sum_{i=1}^{n}\left(\frac{X_i - \bar{X}}{s_X}\right)\left(\frac{Y_i - \bar{Y}}{s_Y}\right)$$

$$r = \frac{\sum_{i=1}^{n}(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum_{i=1}^{n}(X_i - \bar{X})^2}\sqrt{\sum_{i=1}^{n}(Y_i - \bar{Y})^2}}.$$

Correlations by the eye

	Var 1	Var 2	Var 3	Var 4	Var 5
pp 1	1	5	1	3	7
pp 2	2	4	2	2	12
pp 3	3	3	3	3	17
pp 4	2	4	2	4	12
pp 5	3	3	3	3	17
pp 6	3	3	3	2	17
pp 7	4	2	4	3	22
pp 8	5	1	5	4	27
pp 9	4	2	4	3	22
pp 10	5	1	5	2	27

	1	2	3	4	5
1	x	-1	1	0	1
2	-1	x	-1	0	-1
3	1	-1	x	0	1
4	0	0	0	x	0
5	1	-1	1	0	x

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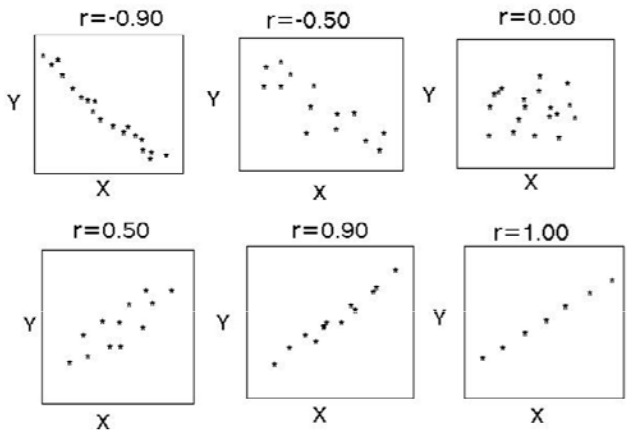
Scatter plots



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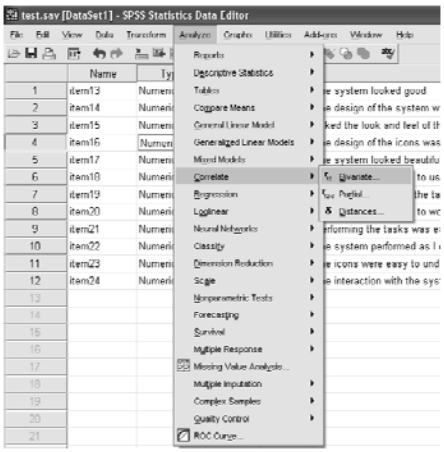
Correlations in SPSS



Correlations are lineair

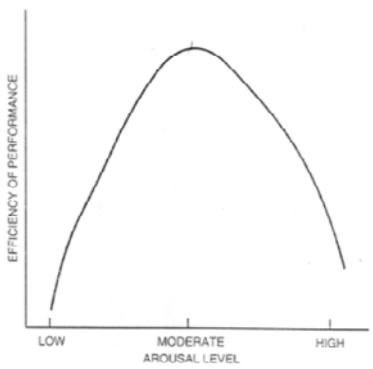


Figure 4-5 Hypothesized relationship between performance efficiency and level of arousal, illustrating a curvilinear relationship.

Reliability analysis

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Types of reliability analysis

- **Scale reliability**
  - **Internal consistency based on correlation**
- **Split-half reliability**
  - **Correlation between similar forms**
- **Test retest reliability**
  - **Correlation between test en second test**
- **Inter-Rater reliability**
  - **Correlation between multiple raters**

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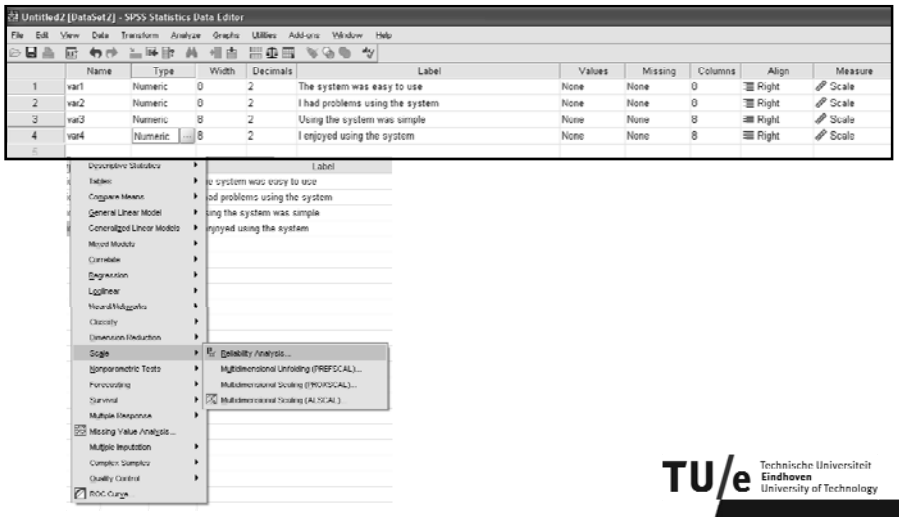
Scale reliability: Practical usage

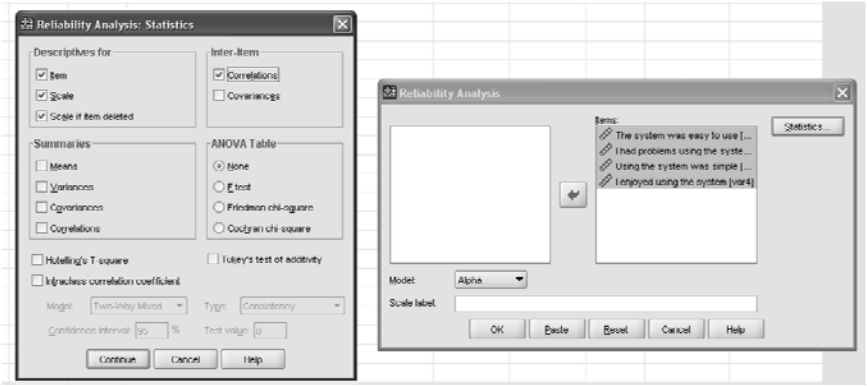
- When you know which construct you are measuring
- When you are only measuring 1 construct
- When dependent variable is of interval or ratio level
- When sample size is sufficient
  - N = 50+5m (m = number of items)
  - N > 300

- CAUTION: Cronbachs Alpha is very dependent on the number of items: Ask the same question 20 times and you are bound to get high values.

Scale reliability



Scale reliability



Scale reliability correlation matrix

Inter-Item Correlation Matrix

	Var 1	Var 2	Var 3	Var 3
Var 1	1,000	-,565	,631	,670
Var 2	-,565	1,000	-,807	-,678
Var 3	,631	-,807	1,000	,662
Var 3	,670	-,678	,662	1,000

Scale reliability SPSS output

Reliability Statistics

Cronbach's Alpha[a]	Cronbach's Alpha Based on Standardized Items[a]	N of Items
-,071	-,061	4

a. The value is negative due to a negative average covariance among items. This violates reliability model assumptions. You may want to check item codings.

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Var 1	12,1667	4,144	,641	,512	-1,747[a]
Var 2	13,1000	20,093	-,786	,689	,847
Var 3	12,7000	4,769	,329	,701	-1,036[a]
Var 3	13,2333	4,668	,551	,585	-1,410[a]

a. The value is negative due to a negative average covariance among items. This violates reliability model assumptions. You may want to check item codings.

How to mirror items

For N point scale

$$X_{i\_mirrored} = (N+1) - X_i$$

After mirroring

Inter-Item Correlation Matrix

	Var 1	Var 3	Var 4	Var 2 Mirror
Var 1	1,000	,631	,670	,565
Var 3	,631	1,000	,662	,807
Var 4	,670	,662	1,000	,678
Var 2 Mirror	,565	,807	,678	1,000

New scale reliability output

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
,889	,890	4

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Var 1	12,2333	21,771	,689	,512	,882
Var 3	12,7667	18,323	,806	,701	,840
Var 4	13,3000	21,183	,757	,585	,859
Var 2 Mirror	13,1000	20,093	,786	,689	,847

Split half reliability

- **Internal consistency reliability**
  - **Correlation between two sets of items measuring the same hypothetical construct**
  - **High correlation means high internal consistency**

Test-retest reliability

- **Test stability over time**
  - **If I measure your EQ now, it should not be totally different next week**
  - **Correlation between test scores administered in multiple points over time**

Inter-Rater reliability

- **Consistency (homogeneity) between raters**
  - **Observation studies**
  - **Number of similar ratings**
  - **High correlation means reliable scoring system.**

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Factor analysis

If we want to do just a little bit more..

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What is factor analysis

- **Method of “restructuring” a large number of items into a more feasible small set of factors.**
- **For Data Reduction: Principal Component Analysis**
- **For Structure Detection: Principal Axis Factoring**
- **Two questions:**
  - **How many components (factors) are needed to represent the variables?**
  - **What do these components represent?"**

Confirmatory verus Exploratory

- **Confirmatory factor analysis:**
  - **Confirms the hypothesized structure of the items**
  - **Used when underlying variables and constructs are well defined.**
- **Exploratory factor analysis:**
  - **Explore possible relations and factor structures**
  - **Used in early development for less well defined variables and constructs.**

Steps to perfoming factor analysis

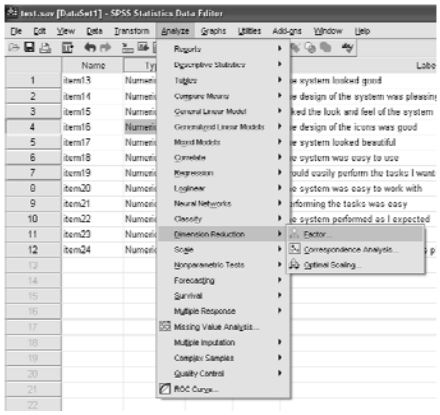
- **Determine items**
  - **Use your generated item set**
- **Get sufficient N**
  - **Minimum 100**
  - **Minimum 300**
  - **50 + 5*m**
- **Determine number of factors**
  - **Scree plot, Eigenvalues, Explained variance**
- **Rotate the factor solution for a simpler structure**
  - **Varimax, Oblimin**
- **Compute factor scores**
  - **Regression**

Example: Our items

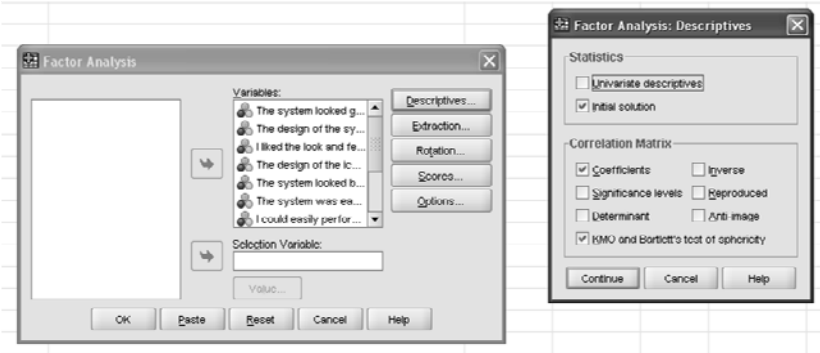
1. The system looked good
2. The design of the system was pleasing
3. I liked the look and feel of the system
4. The design of the icons was good
5. The system looked beautiful
6. The system was easy to use
7. I could easily perform the tasks I wanted to perform
8. The system was easy to work with
9. Performing the tasks was easy
10. The system performed as I expected
11. The icons were easy to understand
12. The interaction with the system was pleasant

All on a 5-point scale (Totally disagree, totally agree)
(N=1428)

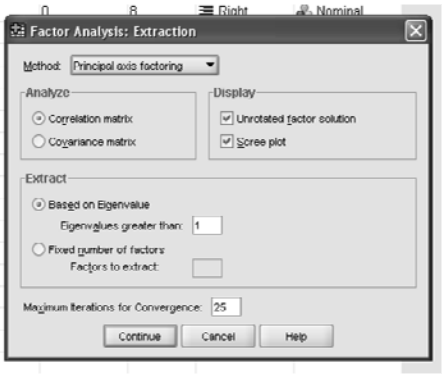
Principal axis factoring SPSS

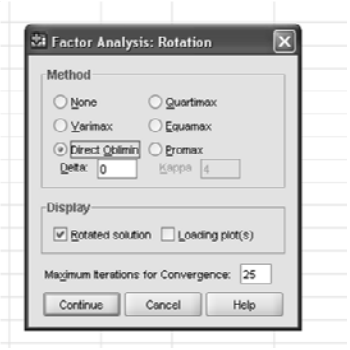


PAF SPSS 2



PAF SPSS 3





KMO and Bartlett's test

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,935
Bartlett's Test of Sphericity	Approx. Chi-Square	8890,014
	df	66
	Sig.	,000

- **KMO**
  - **Index magnitude of observed correlations versus partial correlations**
  - **> 0.8**
- **Barlett's**
  - **Test of correlation of the variables**
  - **Should be significant: Sig. < 0.05**

Communalities

Communalities

	Initial	Extraction
The system looked good	,566	,665
The design of the system was pleasing	,566	,626
I liked the look and feel of the system	,555	,600
The design of the icons was good	,433	,444
The system looked beautiful	,582	,619
The system was easy to use	,570	,663
I could easily perform the tasks I wanted to perform	,460	,544
The system was easy to work with	,330	,366
Performing the tasks was easy	,511	,550
The system performed as I expected	,400	,452
The icons were easy to understand	,661	,644
The interaction with the system was pleasant	,528	,466

Extraction Method: Principal Axis Factoring.

- **Communality**
  - **Measures the percent of variance in a given variable explained by all the factors jointly.**
  - **Example:**
    - **Factor solution explains the system "looking good" very well, but poorly explains the "perfomed as expected" item**

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Total variance explained

Total Variance Explained

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	6,271	52,260	52,260	5,839	48,655	48,655	5,126
2	1,234	10,283	62,543	,800	6,669	55,324	4,813
3	,711	5,926	68,469				
4	,608	5,066	73,535				
5	,564	4,697	78,232				
6	,499	4,155	82,387				
7	,470	3,914	86,301				
8	,384	3,196	89,497				
9	,369	3,074	92,571				
10	,329	2,745	95,316				
11	,309	2,574	97,890				
12	,253	2,110	100,000				

Extraction Method: Principal Axis Factoring.

a. When factors are correlated, sums of squared loadings cannot be added to obtain a total variance.

- **Variance in the items explained by the factors**
- **Cumulative > 60%**
- **If Eigenvalue < 1 – Factor explains less variance than individual item**

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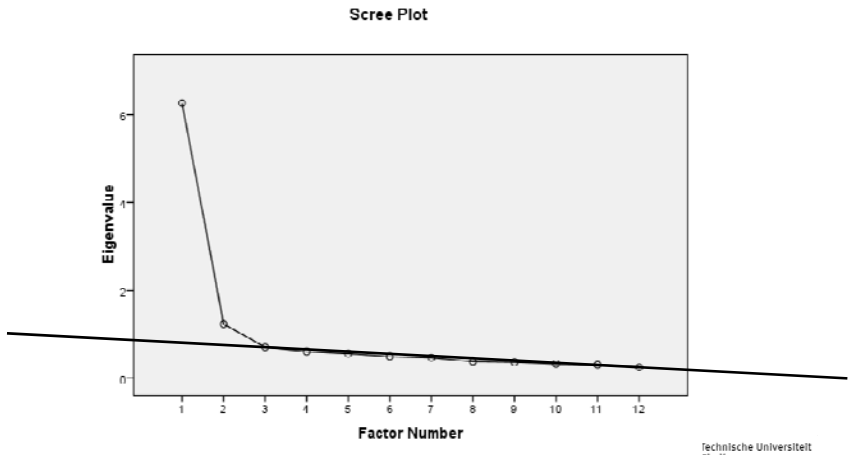
Scree plot



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Factor matrix

Factor Matrix[a]

	Factor	
	1	2
The system looked good	,718	-,388
The design of the system was pleasing	,714	-,341
I liked the look and feel of the system	,734	
The design of the icons was good	,639	
The system looked beautiful	,784	
The system was easy to use	,737	,347
I could easily perform the tasks I wanted to perform	,613	,410
The system was easy to work with	,555	
Performing the tasks was easy	,731	
The system performed as I expected	,619	
The icons were easy to understand	,802	
The interaction with the system was pleasant	,682	

Extraction Method: Principal Axis Factoring.

a. 2 factors extracted. 6 iterations required.

- **Correlations between items and factors**
  - **Factor loadings**
  - **Suppressed values below 0.3**
  - **Factor 1 correlates highly with all items**
  - **Solution not simple to interpret.**
  - **High correlation means highly representative for the factor**

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Rotation

- To create a simpler to interpret factor solutions one can "rotate" the original factor solution.
  - Changes factor loadings
  - Eigenvalues / explained variance remains the same
- Varimax
  - Ortogonal rotation
  - No correlations between factors
- Oblimin
  - Factors can be correlated
  - Realistic

Oblimin rotation

Pattern Matrix[a]

	Factor	
	1	2
The system looked good	,889	
The design of the system was pleasing	,831	
I liked the look and feel of the system	,731	
The design of the icons was good	,607	
The system looked beautiful	,555	,302
The system was easy to use		,794
I could easily perform the tasks I wanted to perform		,810
The system was easy to work with		,572
Performing the tasks was easy		,518
The system performed as I expected		,632
The icons were easy to understand	,509	,370
The interaction with the system was pleasant	,397	,352

Extraction Method: Principal Axis Factoring.
Rotation Method: Oblimin with Kaiser Normalization.

a. Rotation converged in 10 iterations.

- Factor loadings after rotating
  - Factor one: design of the system
  - Factor two: Ease of use
  - Use highest correlations to name the factors
- Correlation factors: 0.6

Recapp

What did we talk about?

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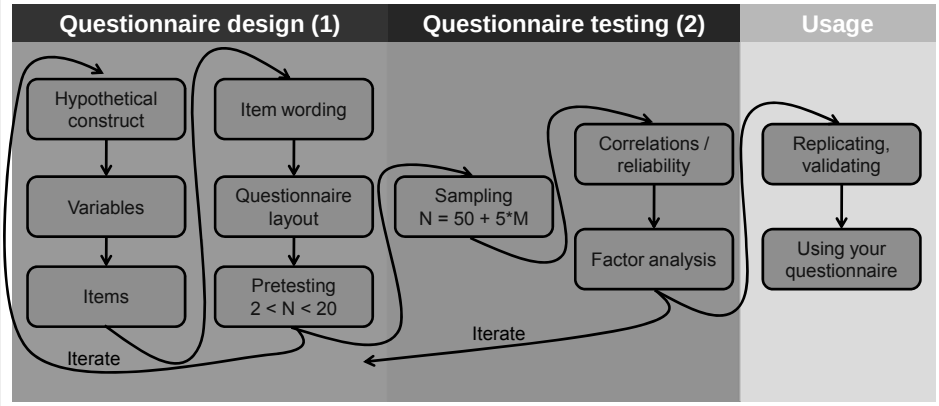
Where innovation starts

/ Industrial Design

The design process



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/ Industrial Design

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Measuring the Subjective User eXperience

End of tutorial

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Where innovation starts

Industrial Design