Validation of an instrument

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Validation of an instrument

• An instrument: is a data collecting tool that we use to gather and record information about our research interests.
  – Self-report
  – Surveys, questionnaires, tests, inventory
  – Paper-and-pencil
  – Online
Validation of an instrument

• Educational tests and regular surveys
  – Higher stake tests: such as credentialing tests (there is a passing score involved) systematic and thorough methods are required.
  – We focus on lower stake tests/scales measuring social and psychological phenomena.
Weakness of using surveys to collect data

- By design: surveys limit data acquisition.
- Surveys are subject to misinterpretation.
- Qualitative methods can produce rich and thick information.
Validation of an instrument

• Why we need to develop a new survey/instrument/questionnaire?
  – The measurement scale of interest doesn’t exist.
  – Or the existing survey is not enough for your research.
Validation of an instrument

• Why we need to validate a new survey?
  – We want to know whether the survey is measuring what is was designed to measure.
  – Accuracy of a measurement
Steps of survey development

- Handbook of test development: “Effective test development requires a systematic, well-organized approach to ensure sufficient validity evidence to support the proposed inferences from the test scores.”
Steps for survey development

- Step 1: Determine what you want to measure
- Step 2: Generating an item pool
- Step 3: Determine the format for items
- Step 4: Expert review of initial item pool
- Step 5: Add social desirability items
- Step 6: Pilot testing and item analysis
- Step 7: Administer instrument to a larger sample
- Step 8: Evaluate the items
- Step 9: Revise instrument

DeVellis (2012); Fishman & Galguera (2003); Pett, Lackey, & Sullivan (2003)
Steps for survey development

- Procedure of survey development

Colton & Covert (2007)
Fundamental issues

- Fundamental issues in survey development or psychological measurements
  - Reliability of new instrument
  - Validity of new instrument
Reliability

• Scale reliability: the consistency or stability of estimate of scores measured by the survey over time.
• Reliability: in other words, scale reliability is the proportion of variance attributable to the true score of latent variable.
  – Reliability = true score/observed score
Latent variables

- Something exist and influence people’s behaviors but they are intangible: self-esteem, depression, anxiety, etc.
- Multiple items may be needed to capture the essence of those variables.
Latent variables

• Latent variables
  – We try to develop a collection of items to represent the level of an underlying theoretical variable (latent variable).
Latent variables

- Theory of Planned Behavior (TPB)
They are latent variables
Reliability

• Classical test theory (CTT): observed score = true score + error
• Measurement error: the more error, the less reliable
  — Systematic error: consistently reoccurs on repeated measures of the same instrument.
• Problems with the underlying construct (measure a different construct: affect validity)
Reliability

• Random error
  – Inconsistent and not predictable
• Environment factors
• Administration variations
Reliability

• How to test reliability
  – Internal consistency
  – Test-retest reliability
  – Split-half reliability
Reliability

• Internal consistency
  – Homogeneity of items within a scale
  – Items share a common cause (latent variable)
  – Higher inter-item correlations suggest that items are all measuring the same thing.
Reliability

• Measures of internal consistency
  – Cronbach’s alpha (between 0 and 1)
  – Kuder-Richardson formula 20 or KR-20 for dichotomous items
  – Reliability analysis using SPSS (Cronbach’s alpha): data can be dichotomous, ordinal, or interval, but the data should be coded numerically.
Cronbach’s alpha: how closely related a set of items are as a group. A "high" value of alpha is often used as evidence that the items measure an underlying (or latent) construct. However, a high alpha does not imply that the measure is unidimensional.
Obtain Cronbach’s alpha using SPSS

- Example: 14 questions regarding dentists’ opinion about OSA.
- How to get reliability coefficient
- Go to Analyze > Scale > Reliability Analysis in SPSS
Reliability

• In SPSS
Reliability

- SPSS output

### Reliability

**Scale: ALL VARIABLES**

<table>
<thead>
<tr>
<th>Case Processing Summary</th>
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<tr>
<td></td>
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<td>Cases Valid</td>
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<td>Excluded</td>
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<td>Total</td>
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</table>

a. Listwise deletion based on all variables in the procedure.

### Reliability Statistics

<table>
<thead>
<tr>
<th>Cronbach's Alpha</th>
<th>N of Items</th>
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<tbody>
<tr>
<td>.835</td>
<td>14</td>
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Reliability

• Test-retest reliability (temporal stability)
  – Give one group of items to subjects on two separate occasions.
  – The scores from the first occasion could be correlated with those from the second occasion.
Reliability

• Split-half reliability
  – Compare the first half items to the second half
  – Compare the odd-numbered items with the even-numbered items
Reliability

• Obtain Split-half reliability coefficient using SPSS: go to Analyze > Scale > Reliability Analysis
Reliability

- SPSS output

<table>
<thead>
<tr>
<th>Reliability Statistics</th>
<th>Part 1</th>
<th>Value</th>
<th>Part 2</th>
<th>Value</th>
<th>Total N of Items</th>
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<tr>
<td>Cronbach's Alpha</td>
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<td></td>
<td></td>
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<tr>
<td>N of Items</td>
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<td></td>
<td>7&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
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<td>Correlation Between Forms</td>
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<td>Spearman-Brown Coefficient</td>
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<td>Unequal Length</td>
<td>.771</td>
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<td>Guttman Split-Half Coefficient</td>
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<td>.767</td>
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</table>

- The items are: q21o, q22o, q23o, q24o, q25o, q26o, q27o.
- The items are: q28o, q29o, q30o, q31o, q32o, q33o, q34o.
Reliability

- Rule of thumb: strength of correlation
  - .00-.29 weak
  - .30-.49 low
  - .50-.69 moderate
  - .70-.89 strong
  - .90-1.00 very strong

Reliability

- Cronbach’s alpha
  - Below .60 unacceptable
  - Between .60 and .65 undesirable
  - Between .65 and .70 minimally acceptable
  - Between .70 and .80 respectable
  - Between .80 and .90 very good
  - Above .90, should consider shortening the scale

DeVellis (2012)
Validity

- Validity: the scale truly measures what it is supposed to measure.
  - Reliability is necessary condition for high quality measurement, but not enough.
  - The reliability of the outcomes depends on the soundness of the measures.
  - Validity is the most fundamental consideration in survey development.
Validity

• Different approaches to investigating validity/evidence of validity
  – Content validity
  – Criterion-related validity: predictive and concurrent validity
  – Construct validity
Standards for test development

- Standards for Educational and Psychological Testing 2014
  - American Educational Research Association (AERA)
  - American Psychological Association (APA)
  - National Council on Measurement in Education (NCME)
Validity

• Validation is an investigation into validity.
• Validation is an open-ended process.
• Validation is based on research.
Sources of validity evidence

• Evidence based on test content
  – Test content refers to the themes, wording, and format of the items and guidelines for procedures regarding administration.
  – Content relevance and representativeness
Sources of validity evidence

• Definition of the construct being examined
  – Adequacy of the content
  – Relevance of the content
  – Concerns: how to know the selected items are representative and how to know the items capture the aspects of the construct.
Content-related validity evidence

• It is critical to establish accurate and comprehensive content for an instrument.

• Selection of content is based on sound theories and empirical evidences or previous research.

• A content analysis is recommended.
  – It is the process of analyzing the structure and content of the instrument.
  – Two stages: development stage and appraisal stage
Content-related validity evidence

- Instrument specification
  - Content of the instrument
  - Number of items
  - The item formats
  - The desired psychometric properties of the items
  - Items and section arrangement (layout)
  - Time of completing survey
  - Directions to the subjects
  - Procedure of administering survey
Content-related validity evidence

◆ Content evaluation (Guion, 1977)
  • The content domain must be with a generally accepted meaning.
  • The content domain must be defined unambiguously
  • The content domain must be relevant to the purpose of measurement.
  • Qualified judges must agree that the domain has been adequately sampled.
  • The response content must be reliably observed and evaluated.
Content-related validity evidence

• Content evaluation
  – Clarity of statements
  – Relevance
  – Coherence
  – Representativeness
Sources of validity evidence

• Evidence based on internal structure
  – The degree to which the relationships among instrument items and components conform to the construct on which the proposed relationships are based.
  – Reliability coefficients and corrected item-total correlations
Sources of validity evidence

• Evidence based on internal structure
  – Exploratory factor analysis (EFA) can tell you the number of dimensions of your measurement.
  – The latent constructs (factors) explain the pattern of correlations among measures (items).
Sources of validity evidence

- EFA provides information regarding the number of factors.
- EFA also provides estimates (factor loadings) regarding the strength and direction of influence of factors on individual items.
Sources of validity evidence

• Example of EFA
  – We use same 14 opinion questions
  – Go to Analyze > Dimension Reduction > Factor
Sources of validity evidence

- EFA using SPSS
Sources of validity evidence

• Click Extraction: check Scree plot
Sources of validity evidence

• SPSS output

KMO: measures strength of the relationship among items. It is also a measure of sampling adequacy. Less than .60 means unacceptable.

Bartlett’s Test of Sphericity: test null hypothesis that there is no relationship among the items.
Communality
Ranges from 0 to 1.00, it represents the total amount of variance in each individual item that is explained by the factors (components).
Sources of validity evidence

• SPSS output: total variance explained

Eigenvalues represent the amount of variance (from correlation matrix) associated with each component (factor). The percentage of explained variance is the percentage of variance explained by each component.
Sources of validity evidence

Scree Plot

Eigenvalue vs. Component Number
Sources of validity evidence

• Determine the number of factors
  – Eigenvalue > 1
  – Percent of explained variance
  – Scree plot
Sources of validity evidence

• Rotation: Direct Oblimin (oblique rotation: assume that factors are not independent of one another)

• SPSS output

  Pattern matrix
  A matrix of loading, shows correlations between factors (components) and individual items. They are standardized partial coefficients.

<table>
<thead>
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<th>Component</th>
<th>Component</th>
<th>Component</th>
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<td>2</td>
<td>3</td>
</tr>
<tr>
<td>q21o</td>
<td>0.700</td>
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<td>q25o</td>
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<td>-0.224</td>
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<td>q28o</td>
<td>0.845</td>
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<td>q30o</td>
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<td>q31o</td>
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<td>q32o</td>
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<tr>
<td>q34o</td>
<td>0.786</td>
<td>0.063</td>
<td>0.186</td>
</tr>
</tbody>
</table>

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.
a. Rotation converged in 6 iterations.
Sources of validity evidence

• SPSS output

Structure matrix
A factor loading matrix, shows simple correlations between rotated factors (components) and individual items
Sources of validity evidence

• Evidence based on relationships to other variables
  – Relationships of test scores to external variables to the test.
  – External variables can be measures of criteria, other tests measuring the same/related/different constructs.

– Types
  • Criterion-related evidence (concurrent and predictive)
  • Convergent and Divergent
  • Groups evidence
Criterion-related validity

• An scale is required to have empirical association with a criterion or gold standard.
• Collect data from new developed instrument and from criterion.
Concurrent evidence: validity evidence based on the relationship between test scores and criterion scores obtained at the same time.

Predictive evidence: validity evidence based on the relationship between the test scores and criterion scores collected at a later time.
Convergent and divergent evidence

- Convergent and divergent (discriminant) evidence
  - Convergent: relationship of test scores and similar constructs.
  - Discriminant: relationship of test scores and different constructs.
Group evidence

• This evidence shows that groups that are known to differ on the construct do differ on the test.
Construct validity

• In order to demonstrate construct validity, we should provide evidence that the scale measures what it is supposed to measure.
• Construct validation requires the compilation of multiple sources of evidence.
  – Content validity
  – Item performance
  – Criterion-related validity
Construct validity

• Validity studies should address both the internal structure of the test and external relations of the test to other variables.
  – Internal structure: subdomains or subconstruct
  – External relations: relationships between test measures and other constructs or variables.
Evidence against validity

- Construct-irrelevant variance: the degree to which test scores are affected by processes that are extraneous to the construct.
Evidence against validity

• Construct-irrelevant variance
  – Systematic error
  – May increase or decrease test scores

\[ y = t + e_1 + e_2 \]

\( y \) is the observed score. \( t \) is the true score. 
\( e_1 \) is random error (affect reliability). 
\( e_2 \) is systematic error (affect validity)
Evidence against validity

• Construct underrepresentation: the degree to which a test fails to capture important aspects of the construct.
  – It is about fidelity: as the proportion of program components that were implemented.
  – It is about the dimensions of studied content.
Item analysis

- Item analysis:
  - it is about item performance.
  - Reliability and validity concerns at item level
  - As means of detecting flawed items
  - Help select items to be included in the test or identify items that need to be revised or removed.
Item analysis

• Three aspects of an item’s performance.
  – Item difficulty: how hard the item is.
  – Item consistency
  – Item discrimination: its capacity to discriminate.
Item difficulty

- Knowing the difficulty of the items can avoid making a test so hard or so easy.
  - The optimal distribution of item difficulties is normal distribution.
  - For dichotomous item (correct/wrong), item difficulty is the proportion of people who answered the item correctly.
Item difficulty

• For example (dichotomous item) 90 students out of 100 get correct answers for one item, item difficulty = 90%.
Item difficulty

• For continuous items: use Mean to represent item difficulty.
• For example: we have 14 items, are use four-point scale as response option:
  – 1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly agree.
Item difficulty

• Means for 14 items

<table>
<thead>
<tr>
<th>Item</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Analysis N</th>
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<td>q21o</td>
<td>4.01</td>
<td>.820</td>
<td>154</td>
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<td>q22o</td>
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<td>.642</td>
<td>154</td>
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<td>q23o</td>
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<td>.973</td>
<td>154</td>
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Is mean enough for item difficulty?
Item difficulty

- Distributions of Q21o
• Instrument reliability if item deleted
  – Deletion of one item can increase overall reliability. Then that item is poor item.
  – We can obtain that statistic from Reliability Analysis (SPSS)
Item reliability

<table>
<thead>
<tr>
<th>Item</th>
<th>Scale Mean if Item Deleted</th>
<th>Scale Variance if Item Deleted</th>
<th>Corrected Item-Total Correlation</th>
<th>Cronbach's Alpha if Item Deleted</th>
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<tbody>
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<td>q21o</td>
<td>45.96</td>
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<td>45.68</td>
<td>38.990</td>
<td>.695</td>
<td>.814</td>
</tr>
</tbody>
</table>
Item discrimination

- Item validity
  - Correlation of each item’s response with the total test score minus the score for the item in question.
  - Corrected item-total correlation.
Item discrimination

- Item validity
  - A bell-shaped distribution with its mean as high as possible.
  - Higher correlation for an item means people with higher total scores are also getting higher item score.
  - Items with low correlation need further examination.
### Item discrimination

- Item discrimination

<table>
<thead>
<tr>
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<td>38.990</td>
<td>.695</td>
<td>.814</td>
</tr>
</tbody>
</table>
Administer instrument to a larger sample

- Sample size: no golden rules
  - 10-15 subjects/item
  - 300 cases is adequate
  - 50 very poor
  - 100 poor
  - 200 fair
  - 300 good
  - 500 very good
  - 1000 or more excellent
Administer instrument to a larger sample

• Administration threats to validity
  – Construct underrepresentation
  – Construct irrelevant variance

• Efforts to avoid those threats
  – Standardization
  – Administrator training
Evaluate items and revise instrument

• Item analysis: item performance
• Factor analysis
  – Purposes
  • determine how many latent variables underlie a set of items.
  • label identified factors to help understand the meaning of underlying latent variables.
• Factor analysis
  – Exploratory factor analysis: to explore the structure of a construct.
  – Confirmatory factor analysis: confirm the structure obtained from exploratory factor analysis.
Optimize scale length

• Effects of dropping items
  – Reliability
  – Construct underrepresentation
  – Construct irrelevant variance
Confirmatory factor analysis

• Purpose of CFA: assess the measurement validity.
  – We want to see how well the data fit the proposed model
  – We use AMOS, SAS, Mplus, Liseral etc. to get CFA results
Confirmatory factor analysis

- Proposed model in AMOS: we use two-factor model of previous example

One variable, q33o is removed from CFA.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Component 1</th>
<th>Component 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>q21o</td>
<td>.747</td>
<td>.211</td>
</tr>
<tr>
<td>q22o</td>
<td>.783</td>
<td>.091</td>
</tr>
<tr>
<td>q23o</td>
<td>.193</td>
<td>.899</td>
</tr>
<tr>
<td>q24o</td>
<td>.354</td>
<td>.800</td>
</tr>
<tr>
<td>q25o</td>
<td>.638</td>
<td>.039</td>
</tr>
<tr>
<td>q26o</td>
<td>.164</td>
<td>.752</td>
</tr>
<tr>
<td>q27o</td>
<td>.675</td>
<td>.018</td>
</tr>
<tr>
<td>q28o</td>
<td>.814</td>
<td>-.068</td>
</tr>
<tr>
<td>q29o</td>
<td>.844</td>
<td>.068</td>
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<tr>
<td>q30o</td>
<td>.505</td>
<td>.187</td>
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<tr>
<td>q31o</td>
<td>.651</td>
<td>.133</td>
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<tr>
<td>q32o</td>
<td>.611</td>
<td>.064</td>
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<tr>
<td>q34o</td>
<td>.800</td>
<td>.166</td>
</tr>
<tr>
<td>q33o</td>
<td>-.110</td>
<td>.204</td>
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</tbody>
</table>

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.
Confirmatory factor analysis

- Proposed model
Confirmatory factor analysis

• AMOS output

Models

Default model (Default model)

Notes for Model (Default model)

Computation of degrees of freedom (Default model)

  Number of distinct sample moments: 104
  Number of distinct parameters to be estimated: 40
  Degrees of freedom (104 - 40): 64

Result (Default model)

Minimum was achieved
Chi-square = 131.761
Degrees of freedom = 64
Probability level = .000
Confirmatory factor analysis

• AMOS output

<table>
<thead>
<tr>
<th>Standardized Regression Weights: (Group number 1 - Default model)</th>
</tr>
</thead>
<tbody>
<tr>
<td>q24o &lt;-- Factor2</td>
</tr>
<tr>
<td>q23o &lt;-- Factor2</td>
</tr>
<tr>
<td>q32o &lt;-- Factor1</td>
</tr>
<tr>
<td>q31o &lt;-- Factor1</td>
</tr>
<tr>
<td>q30o &lt;-- Factor1</td>
</tr>
<tr>
<td>q29o &lt;-- Factor1</td>
</tr>
<tr>
<td>q28o &lt;-- Factor1</td>
</tr>
<tr>
<td>q27o &lt;-- Factor1</td>
</tr>
<tr>
<td>q25o &lt;-- Factor1</td>
</tr>
<tr>
<td>q22o &lt;-- Factor1</td>
</tr>
<tr>
<td>q21o &lt;-- Factor1</td>
</tr>
<tr>
<td>q26o &lt;-- Factor2</td>
</tr>
<tr>
<td>q34o &lt;-- Factor1</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Covariances: (Group number 1 - Default model)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor1 &lt;-- Factor2</td>
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</table>

<table>
<thead>
<tr>
<th>Correlations: (Group number 1 - Default model)</th>
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</thead>
<tbody>
<tr>
<td>Factor1 &lt;-- Factor2</td>
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</table>

<table>
<thead>
<tr>
<th>Estimate</th>
<th>S.E.</th>
<th>C.R.</th>
<th>P</th>
<th>Label</th>
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<tbody>
<tr>
<td>Factor1</td>
<td>Factor2</td>
<td>.100</td>
<td>.031</td>
<td>3.235</td>
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<table>
<thead>
<tr>
<th>Estimate</th>
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<tbody>
<tr>
<td>Factor1</td>
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</table>
Confirmatory factor analysis

- Model fit

**CMIN**

<table>
<thead>
<tr>
<th>Model</th>
<th>NPAR</th>
<th>CMIN</th>
<th>DF</th>
<th>P</th>
<th>CMIN/DF</th>
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<tbody>
<tr>
<td>Default model</td>
<td>40</td>
<td>131.761</td>
<td>64</td>
<td>.000</td>
<td>2.059</td>
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<tr>
<td>Saturated model</td>
<td>104</td>
<td>.000</td>
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<tr>
<td>Independence model</td>
<td>13</td>
<td>975.248</td>
<td>91</td>
<td>.000</td>
<td>10.717</td>
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</table>

**Baseline Comparisons**

<table>
<thead>
<tr>
<th>Model</th>
<th>NFI Delta1</th>
<th>RFI rho1</th>
<th>IFI Delta2</th>
<th>TLI rho2</th>
<th>CFI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default model</td>
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<td>.808</td>
<td>.926</td>
<td>.891</td>
<td>.923</td>
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<td>Saturated model</td>
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<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td></td>
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<tr>
<td>Independence model</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
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</tbody>
</table>

**RMSEA**

<table>
<thead>
<tr>
<th>Model</th>
<th>RMSEA</th>
<th>LO 90</th>
<th>HI 90</th>
<th>PCLOSE</th>
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</thead>
<tbody>
<tr>
<td>Default model</td>
<td>.081</td>
<td>.061</td>
<td>.100</td>
<td>.007</td>
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<tr>
<td>Independence model</td>
<td>.245</td>
<td>.231</td>
<td>.259</td>
<td>.000</td>
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</table>
Confirmatory factor analysis

- Graph with standardized coefficients


Reference


References

THANK YOU