Jumpstart Mplus

5. Data that are skewed, incomplete or categorical

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Dr Gabriela Roman
Questions

• How do I deal with missing values?
• How do I deal with non normal data?
• How do I deal with categorical data?
Missing values

• Missing completely at random (MCAR):
  – Missing by design (to avoid fatigue); by chance...

• Missing at random (MAR)
  – Missing values that are function of an unrelated variable; not of the variables(s) under investigation
  – E.g. Depression: Missing values on suicidal thoughts do not depend on the level of suicidal thoughts. It might depend on gender; females being more prone to answer to this question than males.

• Missing not at random (MNAR)
  – Missing values that are function of the variables under investigation
  – E.g. Depression: Missing values on suicidal thoughts that depend on the level of suicidal thoughts: The higher the number of suicidal thoughts a person has, the less likely this person will provide an answer to this question.
Missing values

• MCAR and MAR are “ignorable”
  – Usually no special treatment is needed.
  – In Mplus missing data are imputed.
    • For imputation method:
      • http://www.statmodel.com/discussion/messages/22/22.html
    – Missing are all ( )
    – ML can be used (or robust ML; MLR)

• MNAR = PROBLEM...
  – Consider collecting more data
  – At the very least interpret results with caution.
Missing values

• Missing values need to be identifiable by something (positive or negative; 999, -999).
• MISSING ARE ALL
  • (-999)
  • variable (#);
  • . ;
  • * ;
  • BLANK;
• A note: type = missing not necessary anymore in Mplus

That’s it!
Mplus
Example
### SUMMARY OF DATA

Number of missing data patterns 9

### COVARIANCE COVERAGE OF DATA

Minimum covariance coverage value 0.100

### PROPORTION OF DATA PRESENT

<table>
<thead>
<tr>
<th>Covariance Coverage</th>
<th>SHOW</th>
<th>INTER</th>
<th>SKILL</th>
<th>PLEASE</th>
<th>POSIVIEW</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHOW</td>
<td>0.972</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTER</td>
<td>0.947</td>
<td>0.972</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SKILL</td>
<td>0.943</td>
<td>0.947</td>
<td>0.968</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PLEASE</td>
<td>0.957</td>
<td>0.957</td>
<td>0.954</td>
<td>0.986</td>
<td></td>
</tr>
<tr>
<td>POSIVIEW</td>
<td>0.954</td>
<td>0.954</td>
<td>0.950</td>
<td>0.964</td>
<td>0.979</td>
</tr>
<tr>
<td>WELL</td>
<td>0.950</td>
<td>0.950</td>
<td>0.947</td>
<td>0.964</td>
<td>0.957</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Covariance Coverage</th>
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</thead>
<tbody>
<tr>
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</tr>
<tr>
<td>WELL</td>
</tr>
</tbody>
</table>

The Psychometrics Centre
Non normal data : continuous

• Data that are skewed or kurtosed

• Potential consequences of using non-normal variables
  – Inflated Chi Square
  – Underestimation of CFI and TLI
  – Underestimation of standard errors
Normal distribution curve

![Graph showing a normal distribution with mean and standard deviation labeled.](image)
Kurtosis
Skew

Negative

Positive
Non normal data: continuous

- ML and GLS are robust to minor deviations from normality
  - With a big enough sample size...
- In doubt, use:
  - MLR: Maximum likelihood with robust standard errors
  - WLS: Weighted least square minimise the differences between observed and predicted values. NOT RECOMMENDED
Example

Information Criteria

Akaike (AIC) 5674.598
Bayesian (BIC) 5749.794
Sample-Size Adjusted BIC 5663.545
\((n^* = (n + 3) / 26)\)

Chi-Square Test of Model Fit

<table>
<thead>
<tr>
<th>Value</th>
<th>5.447*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degrees of Freedom</td>
<td>6</td>
</tr>
<tr>
<td>P-Value</td>
<td>0.7096</td>
</tr>
</tbody>
</table>

Scaling Correction Factor 1.0130 for MLR

Satorra-Bentler scaled (mean-adjusted) chi-square: the usual normal-theory chi-square statistic is divided by a scaling correction to better approximate chi-square under non-normality.

The chi-square value for MLR, MLMV, MLR, ULSMV, ULSMV and ULSMV cannot be used for chi-square difference testing in the regular way. MLR, MLR and ULSMV chi-square difference testing is described on the Mplus website. MLMV, ULSMV, and ULSMV difference testing is done using the DIFFTEST option.

RMSEA (Root Mean Square Error Of Approximation)

<table>
<thead>
<tr>
<th>Estimate</th>
<th>0.000</th>
</tr>
</thead>
<tbody>
<tr>
<td>90 Percent C.I.</td>
<td>0.000 0.053</td>
</tr>
<tr>
<td>Probability RMSEA &lt;= .05</td>
<td>0.999</td>
</tr>
</tbody>
</table>

CFI/TLI

| CFI | 1.000 |
| TLI | 1.015 |

Chi-Square Test of Model Fit for the Baseline Model

| Value | 341.921 |
| Degrees of Freedom | 15 |
| P-Value | 0.0030 |

SRMR (Standardized Root Mean Square Residual)

| Value | 0.015 |
Categorical data

- Categorical data that are not approximating normal distribution or that have less than 5 categories should not be treated as continuous.

- This might lead to:
  - Overestimation of Chi square
  - Underestimation of the relationships between the variables
  - Incorrect test statistics and standard errors
Categorical data

• So what to do?
  – In the VARIABLE command, add:
    • CATEGORICAL ARE:
  – Use WLSMV (default estimator when CATEGORICAL is mentioned). Based on polychoric or polyserial correlations. It uses robust standard errors.
  – According to Brown (2006), Mplus is the best software to deal with categorical data!
Mplus

Example
Self Monitoring
The Study

• Self Monitoring in social psychology refers to an individual’s ability or willingness to control their self presentation in social situations.
  – Self Monitoring Questionnaire (Snyder, 1974)
    • 25 statements about behaviours in social situations.
    • Overarching question: Is this statement true to you?
    • Answers = True or False

• We want to assess the factorial validity of a short version (6 questions):
  • I laugh more when I watch a comedy with others than when alone. **SM1**
  • In groups of people, I am rarely the center of attention. **SM2**
  • In different situations and with different people, I often act like very different persons. **SM3**
  • I am not particularly good at making other people like me. **SM4**
  • Even if I am not enjoying myself, I often pretend to be having a good time. **SM5**
  • I'm not always the person I appear to be. **SM6**

• Coding : True = 1 or False = 0
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6. Multiple group

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Objectives

• What is the purpose of multiple group analysis?

• How do I perform multiple group analyses of a measurement model?

• How do I perform multiple group analyses of a causal structure?
Multiple group

General aim: to assess variations of a construct across groups

• More than one sample
  – E.g. The same study was conducted in two countries: USA and UK.

• More than one group within one sample
  – E.g. The questionnaire was answered by boys and girls.
Multiple group

• Questions that can be answered by multiple group analysis:
  – Does the questionnaire function the same way across samples?
  – Is the overall structure similar?
  – Are the factor loadings/regression paths similar?
  – Are the means similar?
  – Are the variances/covariances similar?
  – Are the errors similar?
Study
Study

Box size

Box accessibility

Box fluffiness

Temperature

Cat speed to box
Study

- Box size
- Box accessibility
- Box fluffiness
- Temperature

Cat speed to box
Mplus Example

Multiple group path analysis
Multiple group path analysis

The study

• Can intrinsic and extrinsic motivation predict the amount of students’ work for a course and their final result, depending on the teaching environment?

  – Operationalisation of the variables:
    • Intrinsic and extrinsic motivation: Self report Likert scale 7 points. **INTRIN** **EXTRIN**
    • Amount of work: number of hours per week spent on work, max = 8 hours **WORK**
    • Result = final grade 0 – 100. **FINALR**
Multiple group path analysis

The study

• In three different environments chosen by the teacher:
  1. INSIDE
  2. OUTSIDE
  3. MIXTE
Study

Intrinsic

Extrinsic

Work

Final Result
Study

Intrinsic

Extrinsic

Work

Final Result
Study
Mediation analysis

Intrinsic

Extrinsic

Work

Final Result
Jumpstart Mplus

6. Measurement invariance

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Measurement invariance – Why?

Measurement equivalence (aka invariance):

Why?

• Just because we labelled it depression, doesn’t mean it is depression

• Use of same questionnaire = the construct measured is the same

Steps: Take initial model → place constraints → check if model fit deteriorates
How do you…

• … bake two cakes that are absolutely ‘the same’… without using the same batter?
How do you…

• … bake two cakes that are absolutely ‘the same’… without using the same batter?

<table>
<thead>
<tr>
<th>Cake</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>The same ingredients (can’t use milk in one but water in the other)</td>
<td>The same structure (i.e., the same items, with the same pattern of loadings)</td>
</tr>
<tr>
<td>The same proportions (can’t use 100g of flour and 20 ml of oil in one, but 70g of flour and 50 ml of oil in the other)</td>
<td>Equal factor loadings (i.e., item 1 must have the same loading onto the factor, in each group)</td>
</tr>
<tr>
<td>The same quality of ingredients</td>
<td>Equal intercepts/thresholds</td>
</tr>
</tbody>
</table>
1) Structural invariance (Equal form)
   – Same factor structure present in all groups

2) Weak factorial invariance (Equal loadings)
   – Unit increase in latent variable is associated with comparable increase in indicator in both groups

3) Strong factorial invariance (Equal indicator intercepts)
   – At a given level of the latent variable, indicators have a comparable value in both groups
How to examine it

Tests:

1. Equal form: all CFAs specified in a single model, same factor structure at each time-point

2. Equal factor loadings: The loadings of ‘like’ indicators are equal

3. Equal indicator thresholds: Intercepts/thresholds of ‘like’ indicators are equal
How to examine it

- Constrain parameters of the CFA to be equal in all groups
- Parameters may be:

<table>
<thead>
<tr>
<th>Free</th>
<th>Unknown; analysis finds optimal value to minimize differences between observed and predicted matrices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed</td>
<td>Known; specified by researcher to a specific value (usually 0 or 1)</td>
</tr>
<tr>
<td>Constrained</td>
<td>Unknown; specified by researcher to have certain restrictions, but not to be a specific value</td>
</tr>
</tbody>
</table>

- E.g. if factor loadings are constrained to equality, the analysis finds a single estimate (the best) for all loadings
How to examine it

• The next step: compare chi-squares of the ‘nested’ models.

• [http://home.comcast.net/~sharov/PopEcol/tables/chisq.html](http://home.comcast.net/~sharov/PopEcol/tables/chisq.html)
Comparison of latent means

!!! Comparison of group means only meaningful when measures are equivalent !!!

• Equal variances:
  = The groups drew from similar ranges of the latent variable to respond to its indicators
  – Often does not have substantive implications in applied research, but is a necessary step before comparing means

• Equal means:
  = Groups do not differ in their levels of the latent variable
Comparison of latent means

• Mean of first group is fixed to 0 ➔ group 1 is the ‘reference’ group

• Means of other groups = deviations from the mean of the reference group

• A few points:
  – It is possible to choose the reference group to be other than the first group; switching between groups in the selection of the reference group may be important when more than 2 groups are compared
  – Absolute means are not computed (because all indicator intercepts / thresholds are constrained to be equal)
If measures are not equivalent?

• If full measurement invariance is untenable (significant difference in $\chi^2$), partial measurement invariance is possible

• Why it helps:
  – Allows analysis of measurement invariance to proceed (don’t have to abandon analyses)
  – Can evaluate structural parameters (e.g. mean differences) of model in context of partial measurement invariance
Partial measurement invariance

• **Steps:**
  – Establish that measures are not invariant (chi-square difference = sig.)
  – Check modification indices to identify parameters that are not invariant
  – Relax the constraints on noninvariant parameters

• **Things to consider:**
  – If many indicators are noninvariant, should question whether it is suitable to proceed with further invariance testing
  – May be more problematic when the research interest is psychometric (e.g. test development)
Study

• I- Care:

1. I care about what my family thinks about me.
2. I care about what my partner thinks about me.
3. I care about what my friends think about me.
4. I care about what my pet thinks about me.
Study

1. Family
2. Partner
3. Friends
4. Pet

i-care