Using structural equation modeling to detect measurement bias

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• Measurement bias is defined as a violation of measurement invariance

• Measurement invariance:

$$f_1(X | T = t, V = v) = f_2(X | T = t)$$

- X are measurements (e.g., item scores)
- T is what we want to measure (e.g., math ability)
- V are any other variables (e.g., ethnicity)
1. For every two chickens of farmer A, farmer B has five. All together the farmers have 637 chickens.

What is the number of chickens of farmer B?

(a) 180
(b) 315
(c) 390
(d) 455
Measurement invariance

\[ f_1( X \mid T = t, V = v ) = f_2( X \mid T = t ) \]
Measurement bias (uniform)

\[ f_1(X \mid T = t, V = v) \neq f_2(X \mid T = t) \]
Measurement bias (nonuniform)

\[ f_1(X \mid T = t, V = v) \neq f_2(X \mid T = t) \]
Background

• Mellenbergh (1985, 1989)
  – Conditional independence: \( f_1(X|T,V) = f_2(X|T) \)
  – Item response theory (item bias, DIF)

• Meredith (1993)
  – Measurement invariance
  – Factor analysis

• Oort (1991)
  – Generalizations (multigr., RFA, longit.)
  – Structural equation modeling
Measurement invariance in SEM

• Measurement bias with respect to groups
  – multigroup factor analysis

• Measurement bias with respect to any variable
  – factor analysis with exogenous variables (RFA or MIMIC)

• Measurement bias in longitudinal data
  – longitudinal factor analysis
Latent variable model of the measurement of $T_1$ and $T_2$ through variables $X_1$ through $X_8$, in two groups of respondents.
Bias detection in multigroup SEM

• Measurement bias can be detected by testing:
  – equality constraints on factor loadings
  – equality constraints on intercepts
  – equality constraints on residual variances

• Pros:
  – uniform and nonuniform bias can be detected

• Cons:
  – few group memberships at a time
  – limited to continuous variables (?)
Measurement invariance in SEM

• Measurement bias with respect to groups
  – multigroup factor analysis

* Measurement bias with respect to any variable
  – factor analysis with exogenous variables
    (RFA or MIMIC)

• Measurement bias in longitudinal data
  – longitudinal factor analysis
Bias detection through RFA

Measurement bias

Structural Equation Model
Latent variable model of the measurement of $T_1$ and $T_2$ through measurements $X_1$ through $X_8$, with possible measurement bias in $X_3$ and $X_6$ with respect to possible violators $V_1$ and $V_2$. 
Bias detection in RFA

• Measurement bias can be detected
  – by testing the effect of V on X

• Pros:
  – bias with respect to any variable V can be detected
  – bias with respect to multiple V simultaneously
  – feasible with modest sample sizes

• Cons:
  – only uniform bias can be detected (?)
Bias detection through RFA

Measurement bias

Structural Equation Model
Measurement invariance in SEM

- Measurement bias with respect to groups
  - multigroup factor analysis
- Measurement bias with respect to any variable
  - factor analysis with exogenous variables (RFA or MIMIC)

* Measurement bias in longitudinal data
  - longitudinal factor analysis
Latent variable model of the measurement of $T_1$ and $T_2$ through variables $X_1$ through $X_8$, at two measurement occasions.
Bias detection in longitudinal SEM

• Measurement bias can be detected by testing:
  – equality constraints on factor loadings
  – equality constraints on intercepts
  – equality constraints on residual variances

• Cons:
  – not too many variables at a time
  – larger sample sizes required

• Pros:
  – uniform and nonuniform bias can be detected
  – extension with exogenous V variables (?)
Latent variable model of the measurement of $T_1$ and $T_2$ through variables $X_1$ through $X_8$, at two measurement occasions, with possible response shift caused by $V_1$ and $V_2$. 
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• Frans Oort:
  – Introduction

• Suzanne Jak:
  – Bias in dichotomous item responses

• Mariska Barendse:
  – Non-uniform bias in the RFA method

• Bellinda King-Kallimanis:
  – Bias in longitudinal data