Unintended Consequences of Latent Variable Measurement Modeling

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APS San Francisco, May 24, 2018

Measurement Error

Common wisdom: psychological measures are imprecise
→ heavy focus on measurement error in psychology

$$x = t_x + e_x$$

measured variable

error-free "true" variable

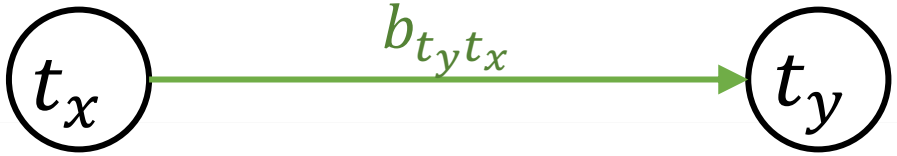
random measurement error

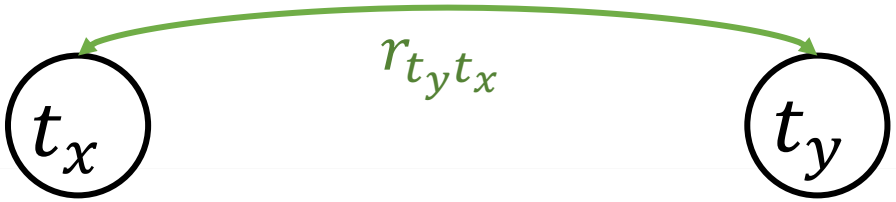
Reliability:

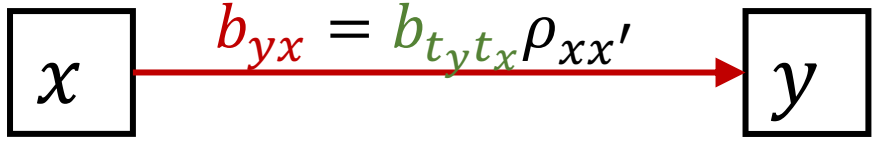
$$\rho_{xx'} = \frac{var(t_x)}{var(t_x) + var(e_x)}$$

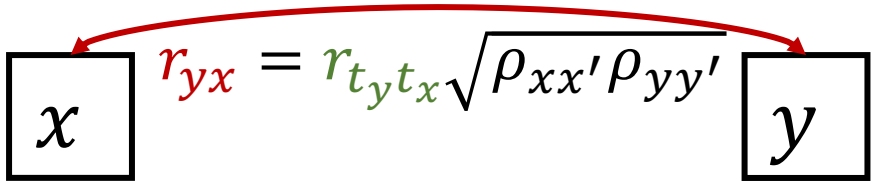
UCDAVIS

Measurement Error



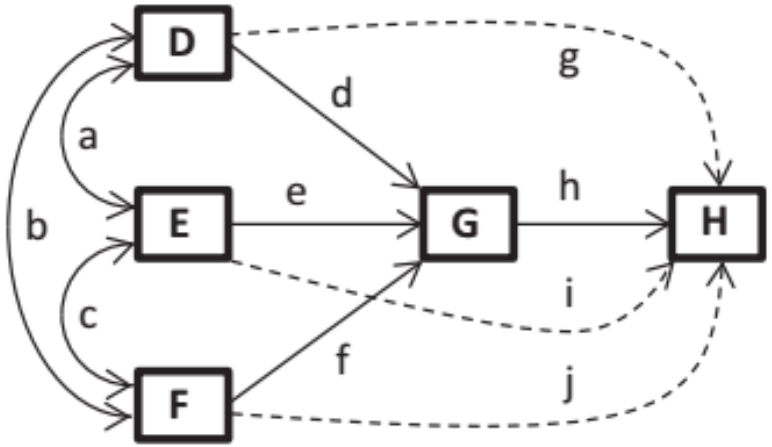






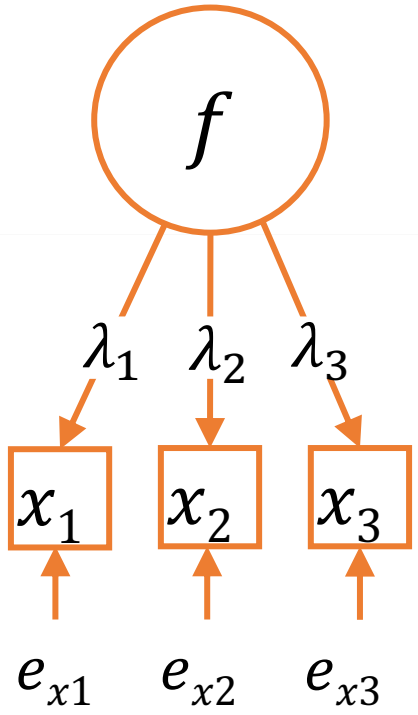
Measurement Error

Cole & Preacher (2013, *Psychological Methods*)



a: $\downarrow_D \downarrow_E$
b: $\downarrow_D \downarrow_F$
c: $\downarrow_E \downarrow_F$
d: $\uparrow_E \uparrow_F \downarrow_D \downarrow_G$
e: $\uparrow_D \uparrow_F \downarrow_G \downarrow_E$
f: $\uparrow_D \uparrow_E \downarrow_F \downarrow_G$
g: $\uparrow_G$
h: $\downarrow_G \downarrow_H$
i: $\uparrow_G$
j: $\uparrow_G$

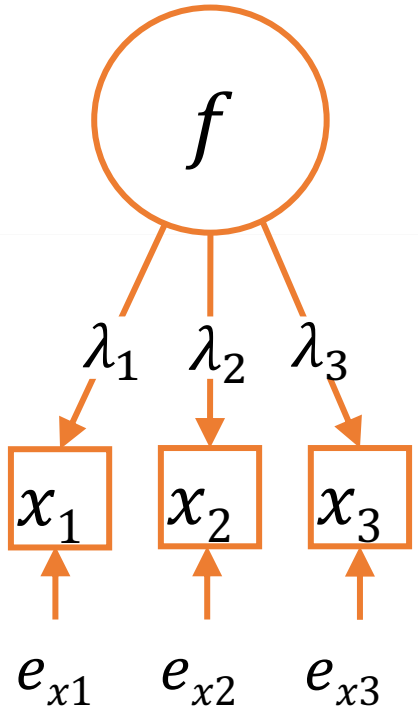
How Latent Variable Models Deal With Measurement Error



Logic of the Common Factor:

- *If* $x_1 - x_3$ are all unreliable measures of the same underlying thing, f
  - x's share the same $t_x = f$
  - only random measurement error distinguishes them
- *Then:*
  - $x_i = f + e_i$
  - all x's are independent conditional on f
  - f is the thing that is shared among x's

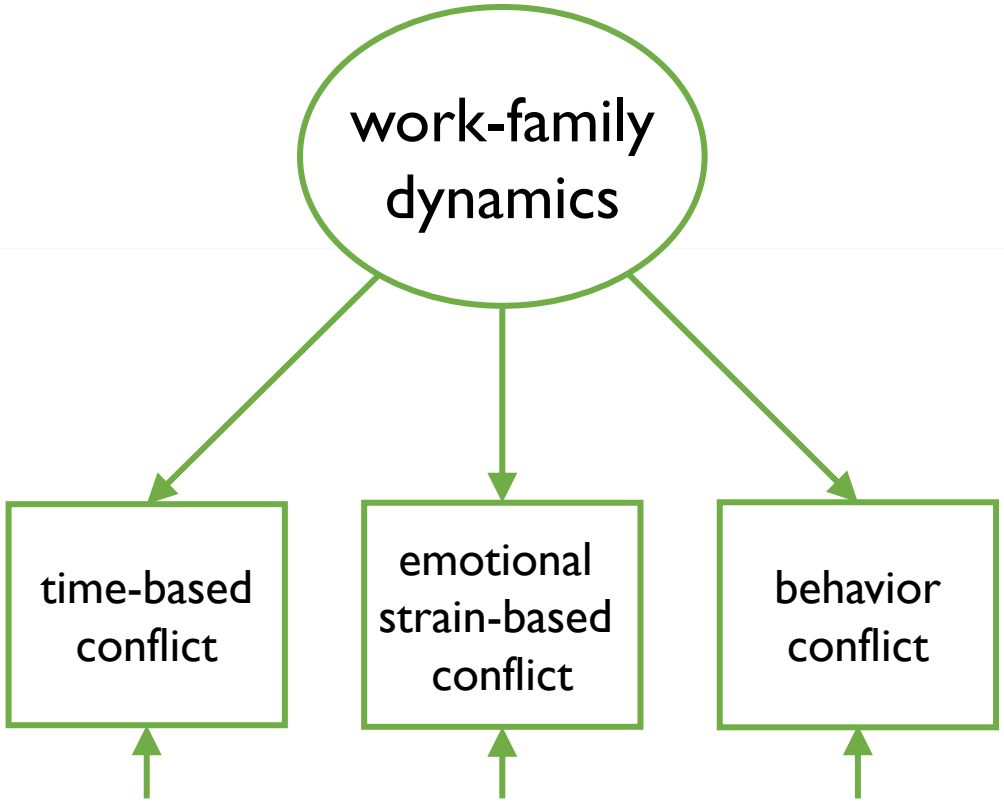
How Latent Variable Models Deal With Measurement Error



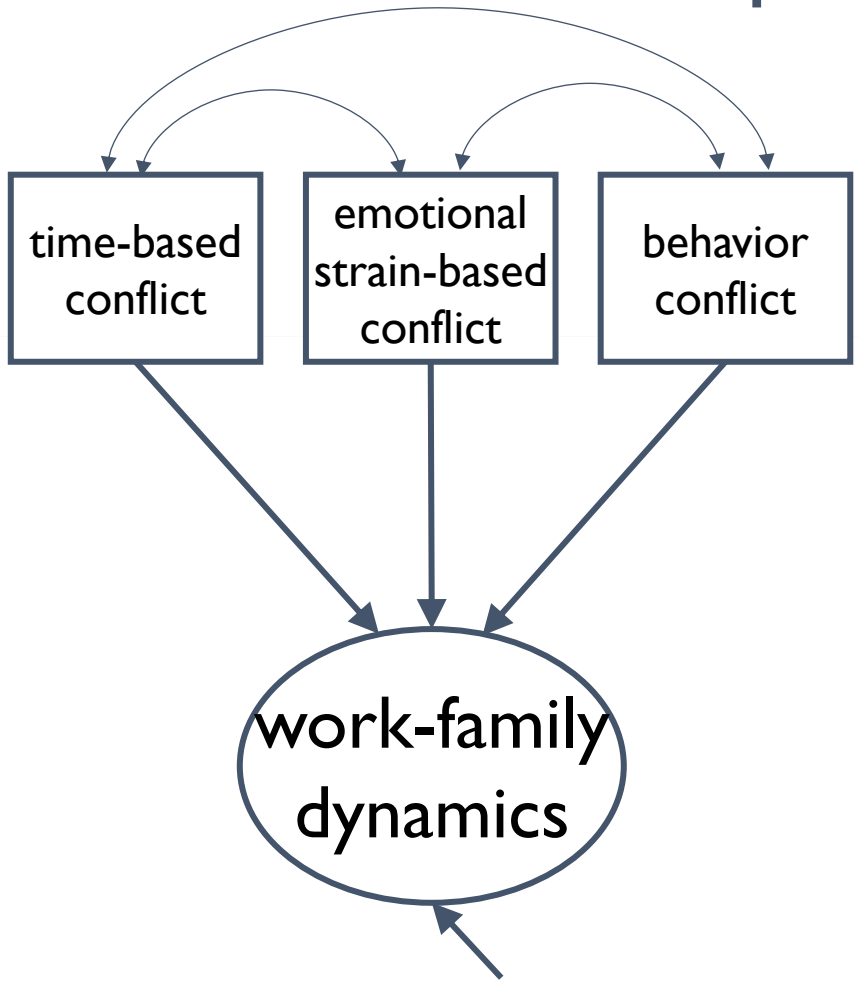
The latent variable model deals appropriately with measurement error IF theory of the construct and items is consistent with the model…

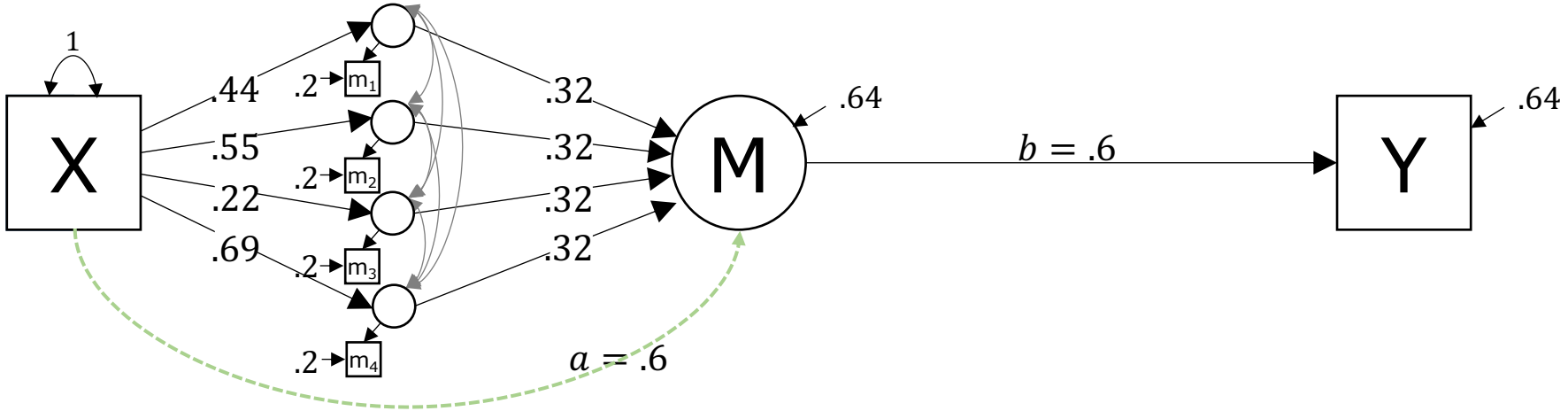
The construct that you want to study must be the same thing as the variance that is common to all indicators

Recent Use of Reflective LV



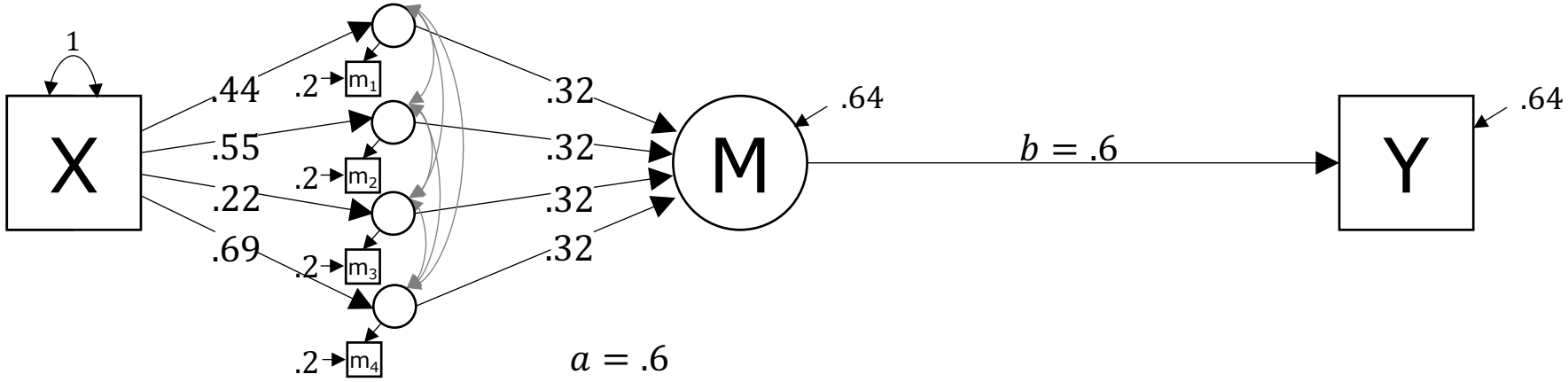
Example: Construct-indicator Relationship Reversed



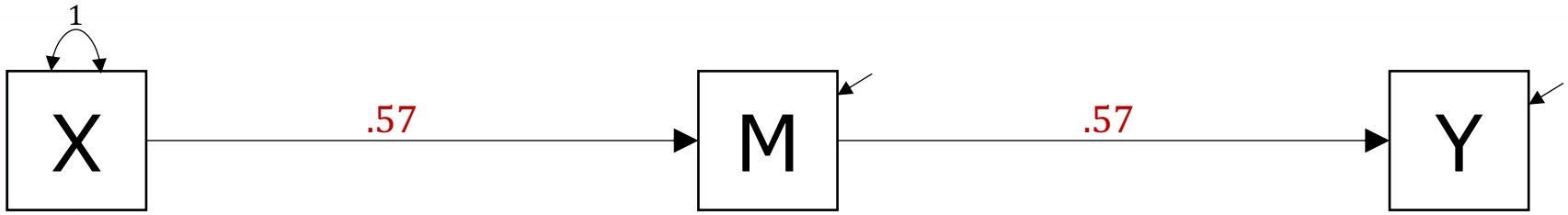


Population Model

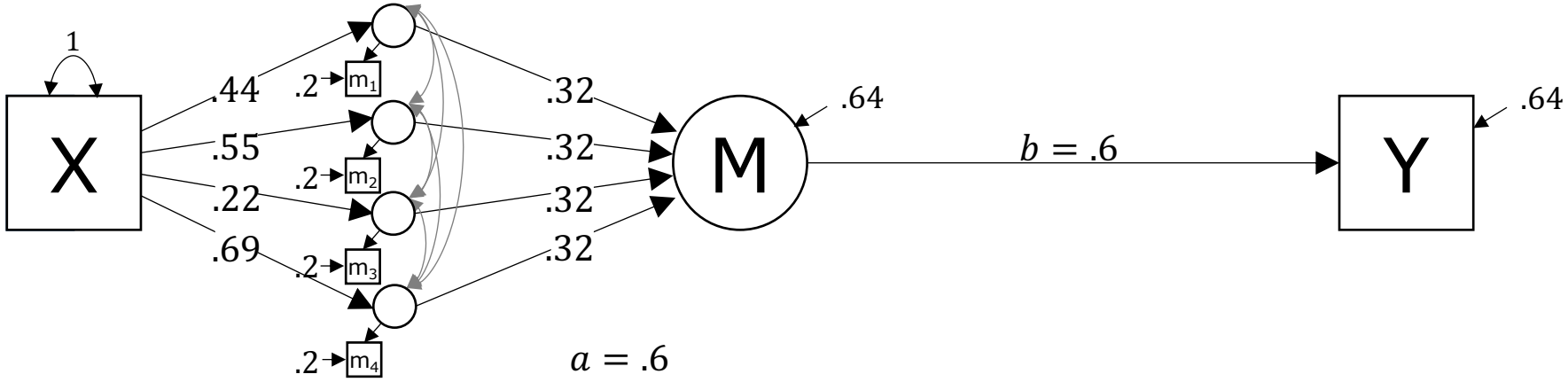
- X differentially affects each true component of M
- Each component of M is measured with 80% reliability
- Each pair of true components of M are equally correlated ($\rho_{true} = .49, \rho_{obs} = .39$)
- The total effect of $X \rightarrow M$ is .6, and the effect of $M \rightarrow Y$ is .6



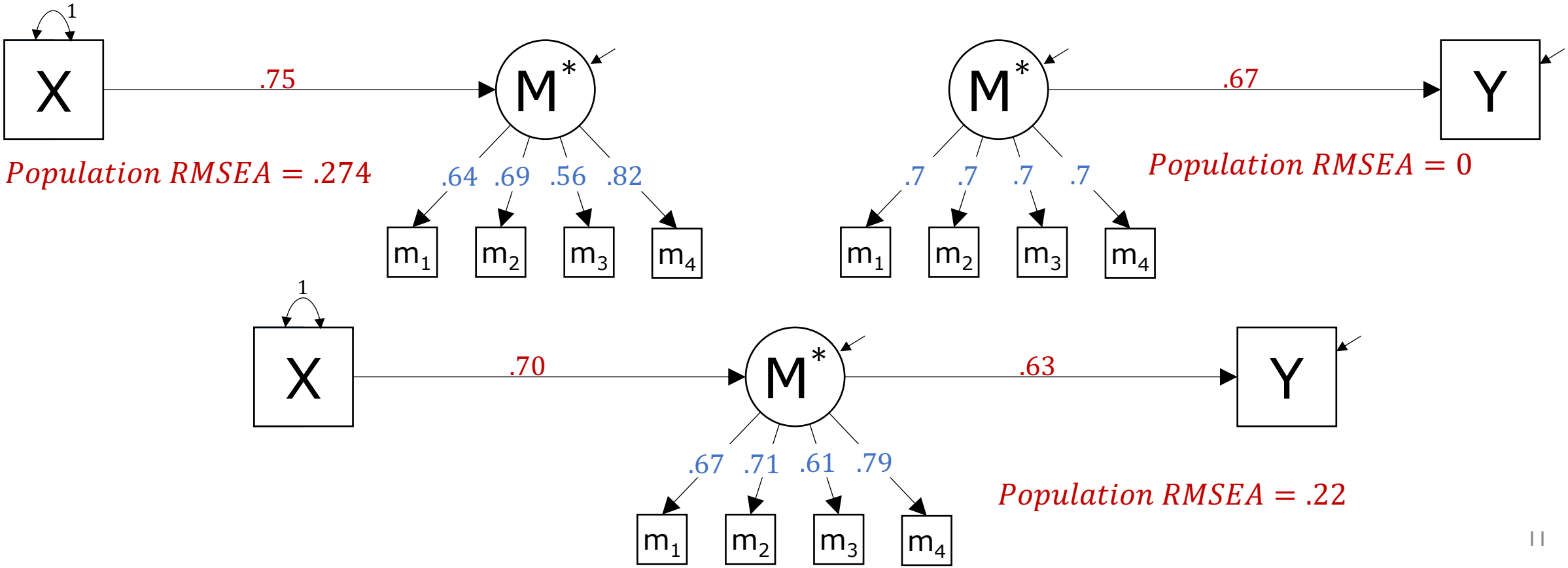
Fitted Composite (Sum-score) Model:



$Population\ RMSEA = .049$



Fitted Latent Variable Models:



Summary

- Conventional wisdom holds that there is no such thing as error-free measurement (Borsboom, 2008)
- Adding the fact that ignoring measurement error leads to incorrect conclusions (Cole & Preacher, 2014; Westfall & Yarkoni, 2016) may lead many people to conclude that using a latent measurement model is always a good bet
- Applying a latent variable model without justification can lead to worse problems than not modeling error

Where do we go from here?

- Whether or not a reflective model is appropriate can often be answered by theory:
  - Is it plausible that a change in the construct causes a change in the indicator, or is it more plausible that a change in the indicator causes a change in the construct?
  - Is it plausible that all indicators are independent conditional on the construct, or are there plausibly direct effects among indicators?
- Methodologists may want to develop statistical tests to diagnose the problem

Thank you!