Comparing Multiple Statistical Software for Multiple-Indicator, Multiple-Cause Modeling: An Application of Gender Disparity in Adult Cognitive Functioning Using MIDUS II Dataset

CURRENT STATUS: UNDER REVIEW

BMC Medical Research Methodology BMC Series

Chi Chang
Michigan State University

chisq@msu.edu*Corresponding Author*
ORCiD: https://orcid.org/0000-0002-2106-2476

Joseph Gardiner
Michigan State University

Richard T Houang
Michigan State University

Yan-Liang Yu
Howard University

DOI:
10.21203/rs.2.20252/v1

SUBJECT AREAS
Health Economics & Outcomes Research

KEYWORDS
MIMIC model, MIDUS II, Statistical Software Comparison, Cognitive Functioning Performance, Structural Equation Model, R, Mplus, SAS

Abstract

Background: The Multiple-indicator, multiple-cause model (MIMIC) incorporates covariates of interest in the factor analysis using structural equation modeling framework. The model provides rigorous results and becomes broadly available in multiple statistical software. The current study introduces the MIMIC model and how it can be implemented using statistical software SAS CALIS procedure, R lavaan package, and M plus version 8.0.

Methods: In this paper, we first discussed the formulation of the MIMIC model with regard to model specification and identification. We then demonstrated the empirical application of the MIMIC model with the Midlife in the United States II (MIDUS II) Study (N=4,109) using SAS CALIS procedure, R lavaan package and M plus version 8.0 to examine gender disparities in cognitive functioning. The input, output, and diagram syntaxes of the three statistical software programs were also presented.

Results In terms of data structure, all three statistical programs can be conducted using both raw data and empirical covariance matrix. While SAS and R are comprehensive statistical analytic packages and encompass numerous data manipulation capacities, M plus is designed primarily for structural equation modeling and therefore is limited in data manipulation. Differences in model results from the three statistical programs are trivial. Overall, the results show that while men show better performance in executive function than women, women demonstrate better episodic memory than men.

Conclusions: Our study demonstrates the utility of the MIMIC model in its empirical application, fitted with three popular statistical software packages. Results from our models align with empirical findings from previous research. We provide coding procedures and examples with detailed explanations in the hopes of providing a concise tutorial for researchers and methodologists interested in incorporating latent constructs with multiple indicators and multiple covariates in their research projects. Future researchers are encouraged to adopt this flexible and rigorous modeling approach.

Full-text

Due to technical limitations, full-text HTML conversion of this manuscript could not be completed. However, the manuscript can be downloaded and accessed as a PDF.

Figures

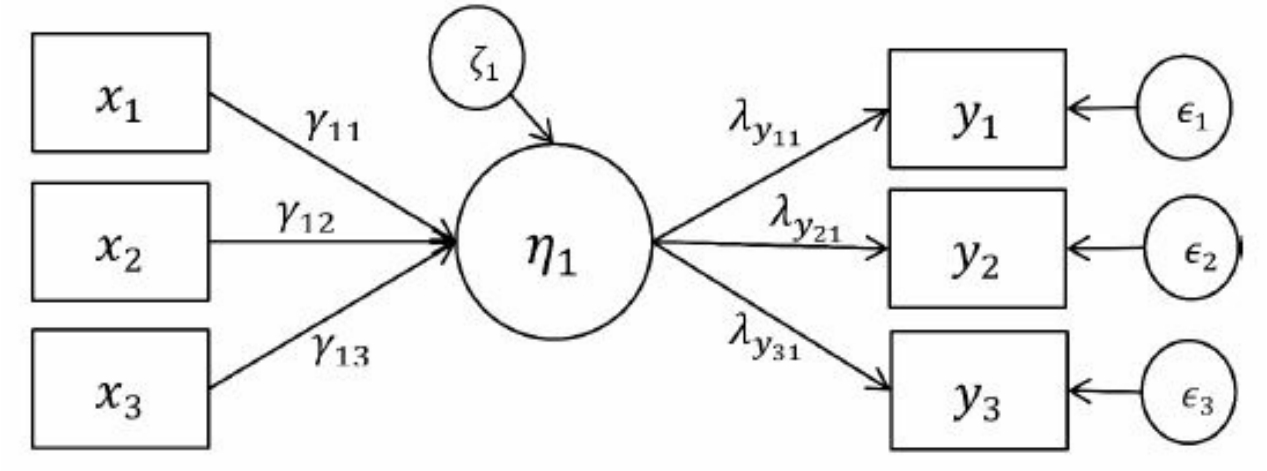

Figure 1

A one-factor MIMIC model

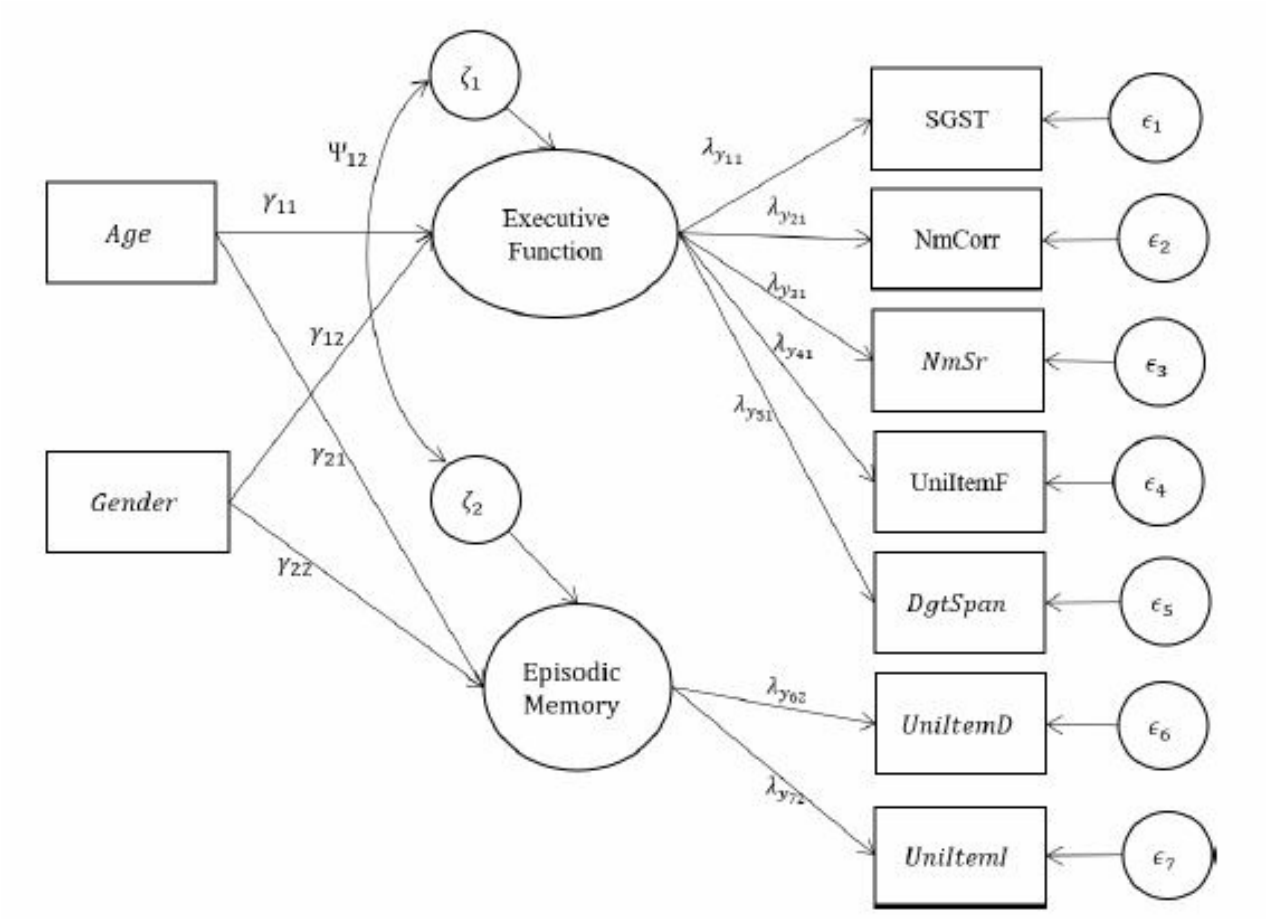

Figure 2

The path diagram of the MIMIC model - Initial Specification

```
ods graphics on;
proc calis data = rdata modification method = ml;
path
    /* measurement model for Episodic Memory*/
    F1 ---> UniItemI = lambda1,
    F1 ---> UniItemD = lambda2,
    /* measurement model for Executive Function*/
    F2 ---> DgtSpan =lambda3 ,
    F2 ---> UniItemF = lambda4,
    F2 ---> NmSr = lambda5,
    F2 ---> NmCorr = lambda6,
    F2 ---> SGST = lambda7,
    /* structural model */
    age ---> F1 = gamma11,
    age ---> F2 = gamma21,
    gender ---> F1 = gamma12,
    gender ---> F2 = gamma22,
    <--> F1 = 1.0  ,
    <--> F2 = 1.0  ,
    <--> age = vage,
    <--> gender = vgender,
    <--> UniItemI UniItemD DgtSpan UniItemF NmSr NmCorr SGST =
    epis11 epis12 epis13 epis14 epis15 epis16 epis17;
    /* sepcify the error (disturbance) covariance*/
pcov
    F1 F2 = covF1F2,
    age gender = covAgeGender;
pathdiagram
    diagram = unstandard exogcov
    title = " MIMIC MODEL"
    label = [ F1 = "Episodic Memory"
              F2 = "Executive Functioning"]
    fitindex = [nobs chisq df probchi srmr rmsea cfi aic];
fitindex on(only) = [chisq df probchi ll_rmsea ul_rmsea rmsea srmr bentlercfi];
run;
ods graphics off;
```

Figure 3

SAS syntax for the MIMIC model

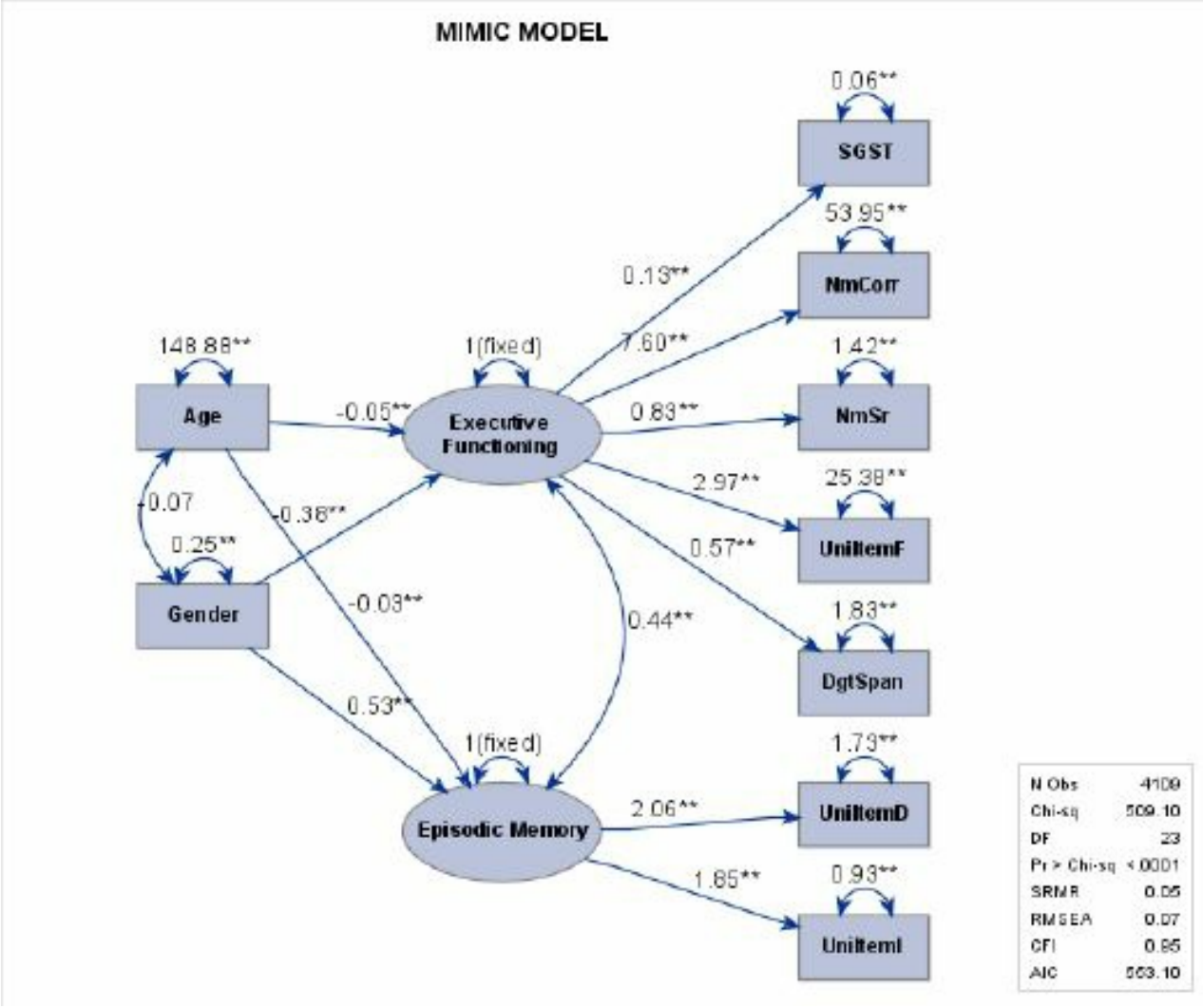

Figure 4

SAS Diagram generated from the pathdiagram statement in SAS syntax

```
Title: MIMIC model
data: file is 'C:\Users\chisq\Dropbox\MIDUS\DataSetCleaned\dataNH.txt';
variable: Names are Age Gender Yr ItemI NmRepI NmIntI ItemD NmRepD NmIntD
DgtSpan ItemF NmRepF NmIntF NmSr lstNm NmErr NmCorr SGST;
usevariables are Age Gender ItemI ItemD ItemF DgtSpan NmSr NmCorr SGST;
model:
    ExeFun by ItemF* DgtSpan NmSr NmCorr SGST;
    EpiMem by ItemI* ItemD;
    EpiMem @1;
    ExeFun @1;
    ExeFun EpiMem on Age Gender;

output: tech1 modindices;
```

Figure 5

Mplus input code for the MIMIC model

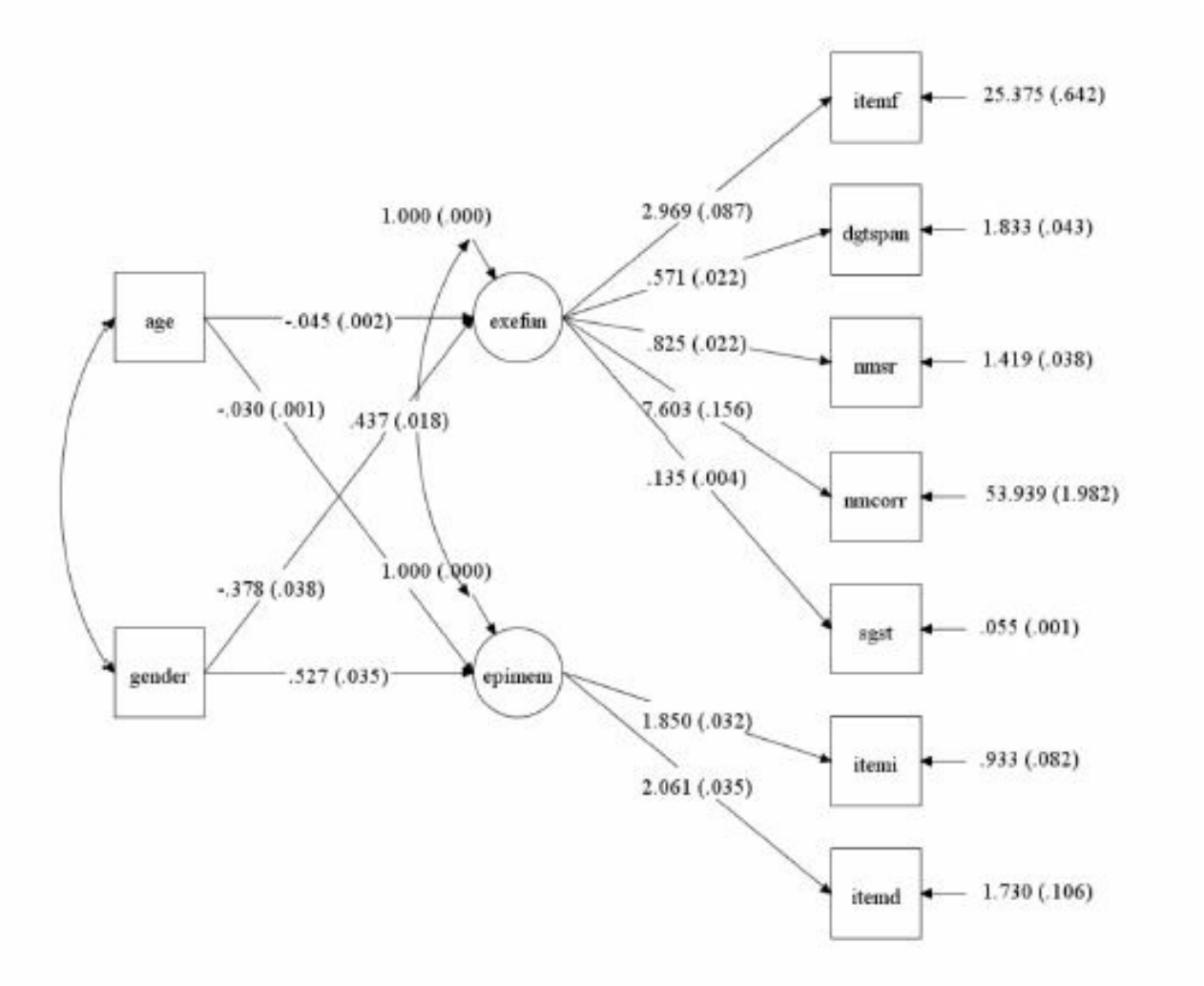

Figure 6

Mplus Diagram for the MIMIC model

```
> library(lavaan)
>
> # write out the measurement model and the structure model
> model <- '
+ EpiMem =~ UniItemI + UniItemD
+ ExeFun =~ DgtSpan + UniItemF + NmSr + NmCorr + SGST
+ EpiMem + ExeFun ~ Age + Gender
+ '
> # fit SEM uing sem function in the 'lavaan' package
> fit <- sem(model, data = data3, std.lv = T)
> summary(fit, fit.measures = T, standardized = T)
```

Figure 7

R code for the MIMIC model

```
# plot the diagram

> semPaths(fit, what = "mod", whatLabels = "Parameters", style = "OpenMx", edge.width =

0.1, edge.color = "black")
```

Figure 8

R code for the MIMIC model diagram

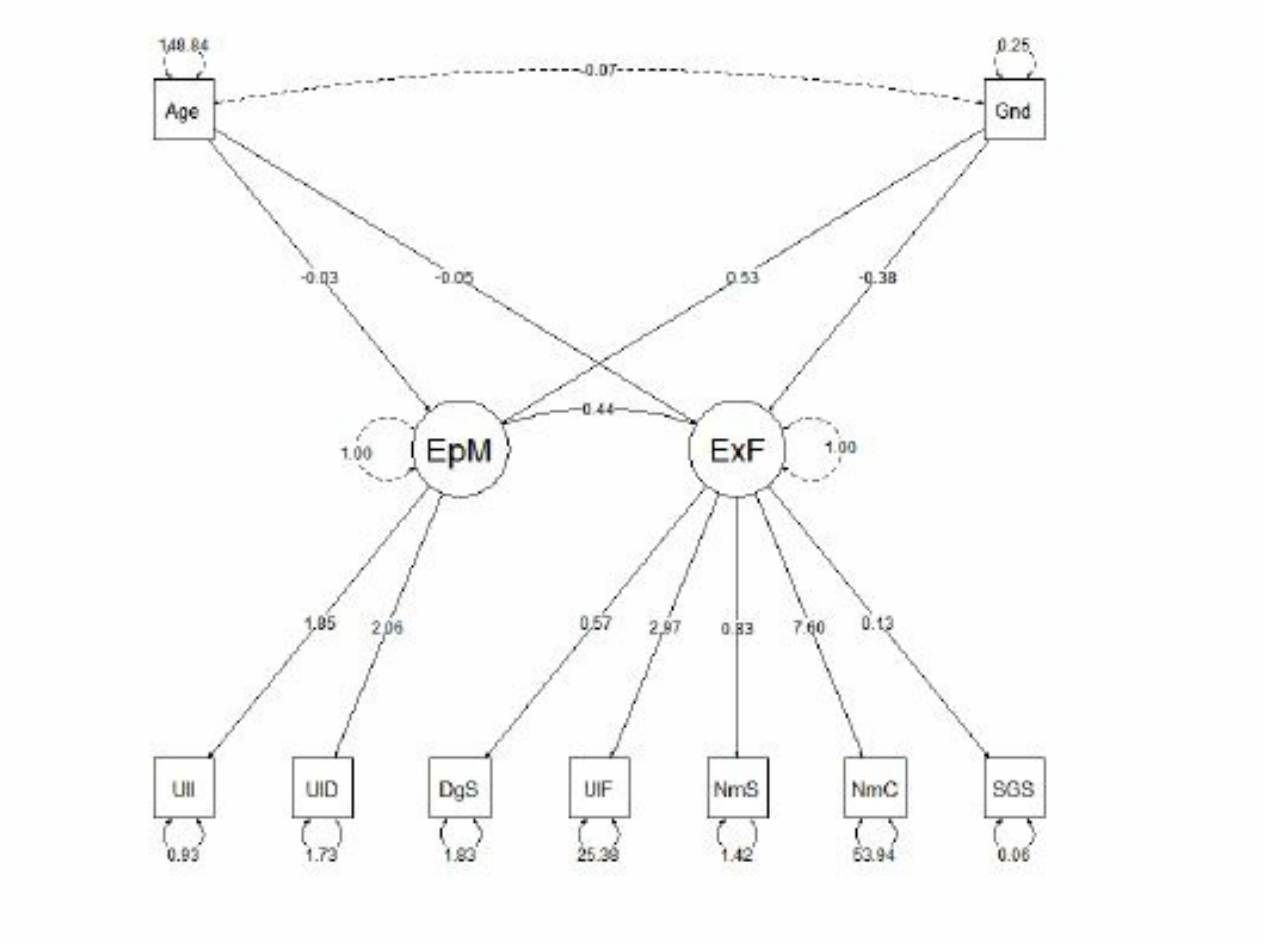

Figure 9

the MIMIC model Diagram from R semPlot package