Introducing Structural Equation Modeling (SEM) to Novices Using Kevin Heslin's SF-36 Data from Opioid Users

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UCLA GIM/HSR Research Seminar Series

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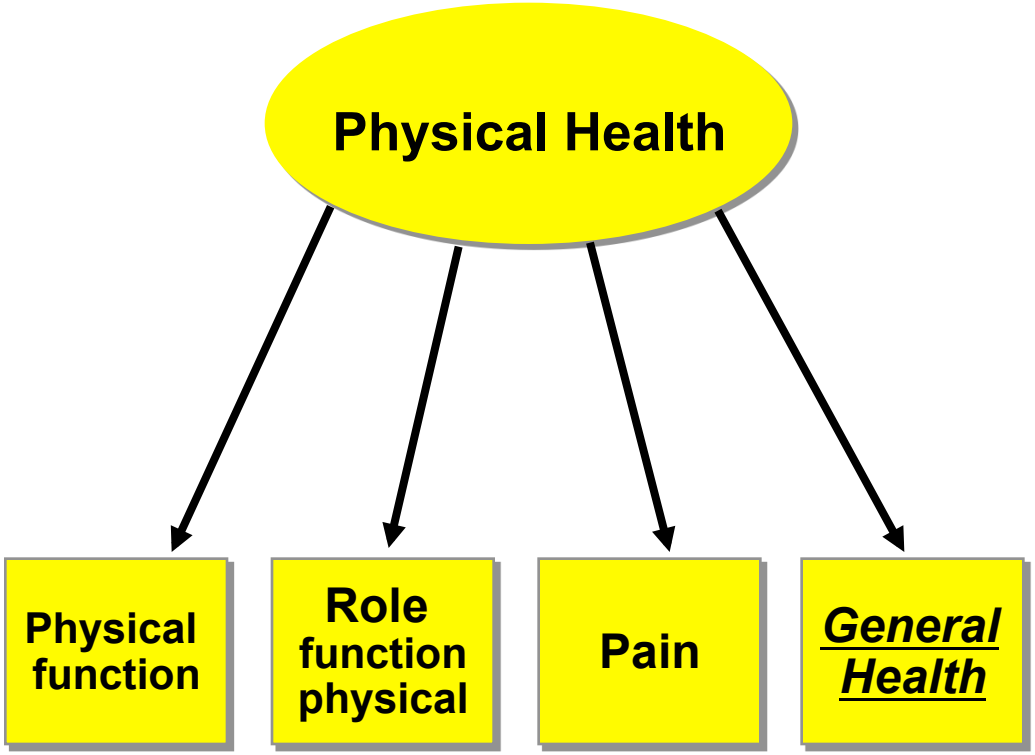
Heslin, K. C., Stein, J., Pan, D., Magladry, C., & Hays, R. D. Determinants of health-related quality of life among clinical trial participants with opioid dependence

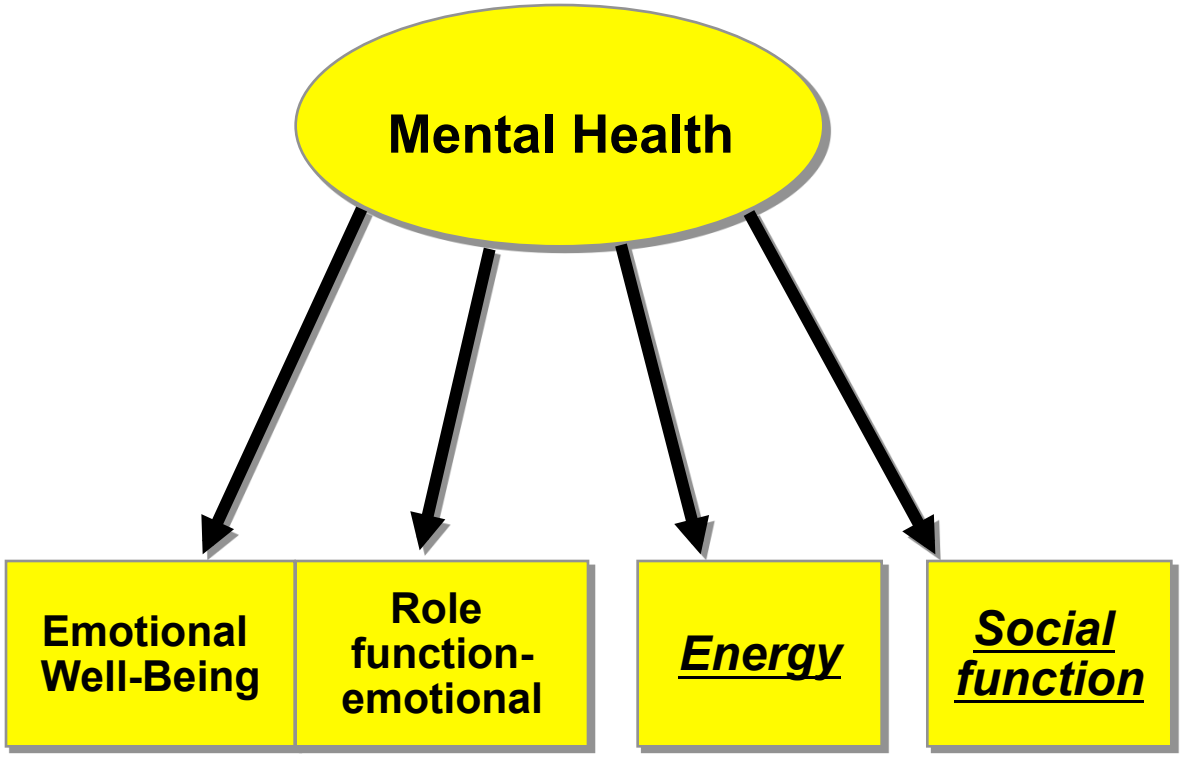
Methods

- Baseline data
  - 344 opioid users (113 inpat.) in multi-center open-label 13-day detox. trial: buprenophrine-naloxone vs. clonidine
  - 12 community-based treatment programs) from NIDA Clinical Trials Network
  - 01/01-02/ 02 (out); 02/01-07/02 (in)
- Dependent variables
  - SF-36 v. 1; Adjective Rating Scale for Withdrawal (ARSW)
- Independent Variables
  - Body Mass Index
  - Pulse Rate
  - Respiratory Rate
  - Systolic Blood Pressure
  - Abnormal Physical Exam Findings
  - Number of Health Conditions

Physical Health



Mental Health



{Module Name} Module

Adjective Rating Scale for Withdrawal

Agency Name: _____ **Site Name:** _____

ID #: _____ **Date:** __ __ / __ __ / __ __ __ __

Please mark the box that best describes how you have been feeling in the last 24 hours.

	None					Moderate				Severe
1. Muscle cramps	❑0	❑1	❑2	❑3	❑4	❑5	❑6	❑7	❑8	❑9
2. Depressed or sad	❑0	❑1	❑2	❑3	❑4	❑5	❑6	❑7	❑8	❑9
3. Painful joints	❑0	❑1	❑2	❑3	❑4	❑5	❑6	❑7	❑8	❑9
4. Excessive yawning	❑0	❑1	❑2	❑3	❑4	❑5	❑6	❑7	❑8	❑9
5. Hot or cold flashes	❑0	❑1	❑2	❑3	❑4	❑5	❑6	❑7	❑8	❑9
6. Trouble getting to sleep	❑0	❑1	❑2	❑3	❑4	❑5	❑6	❑7	❑8	❑9
7. Sick to stomach	❑0	❑1	❑2	❑3	❑4	❑5	❑6	❑7	❑8	❑9
8. Irritable	❑0	❑1	❑2	❑3	❑4	❑5	❑6	❑7	❑8	❑9
9. Runny nose	❑0	❑1	❑2	❑3	❑4	❑5	❑6	❑7	❑8	❑9
10. Poor appetite	❑0	❑1	❑2	❑3	❑4	❑5	❑6	❑7	❑8	❑9
11. Weak knees	❑0	❑1	❑2	❑3	❑4	❑5	❑6	❑7	❑8	❑9
12. Excessive sneezing	❑0	❑1	❑2	❑3	❑4	❑5	❑6	❑7	❑8	❑9
13. Tense, jittery	❑0	❑1	❑2	❑3	❑4	❑5	❑6	❑7	❑8	❑9
14. Watery eyes	❑0	❑1	❑2	❑3	❑4	❑5	❑6	❑7	❑8	❑9
15. Abdominal cramps	❑0	❑1	❑2	❑3	❑4	❑5	❑6	❑7	❑8	❑9
16. Fitful sleep	❑0	❑1	❑2	❑3	❑4	❑5	❑6	❑7	❑8	❑9

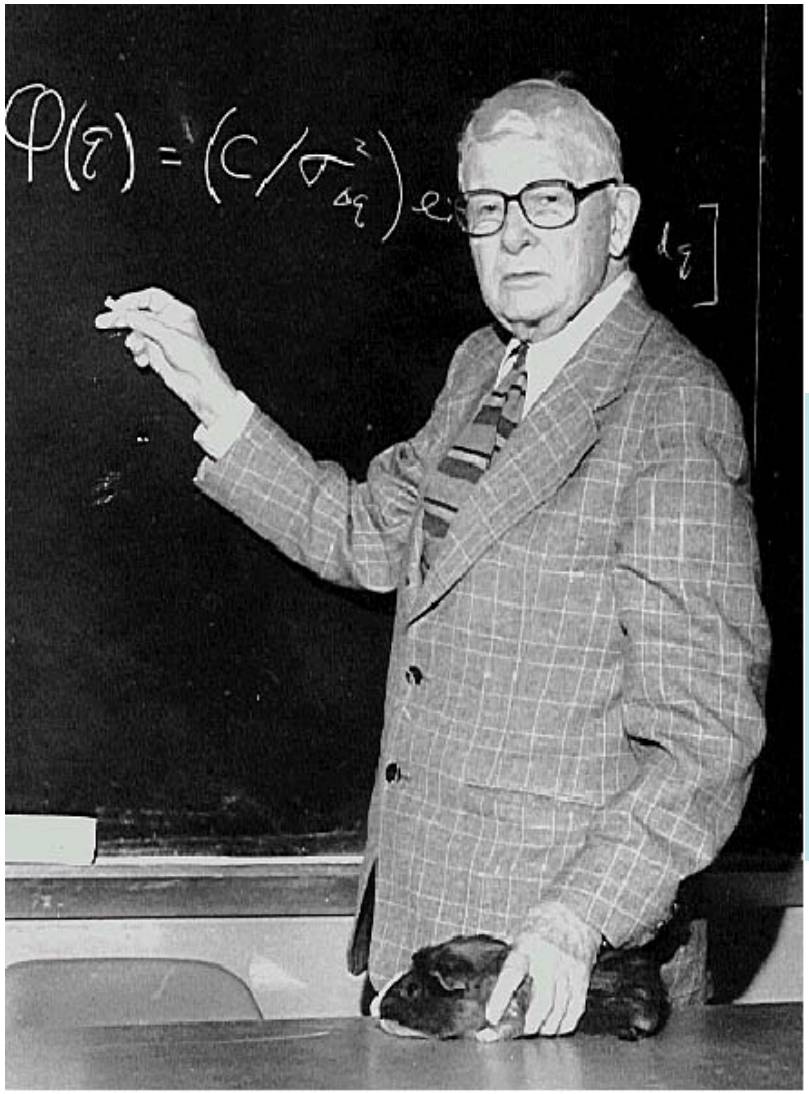
Sample Characteristics

Scale	Mean Score
Physical functioning	50
Role limitations—physical	45
Bodily pain	47
General health perceptions	45
Emotional well-being	38
Role limitations—emotional	39
Energy	44
Social functioning	39

Variable	Mean	Range
BMI	25	16- 46
Pulse	76	47-131
Resp. rate	17	1-31
SBP	122	94-182
Exam	1.2	0-8
Conditions	2.2	0-10

36% Female
45% White; 31% AA
19% Hispanic

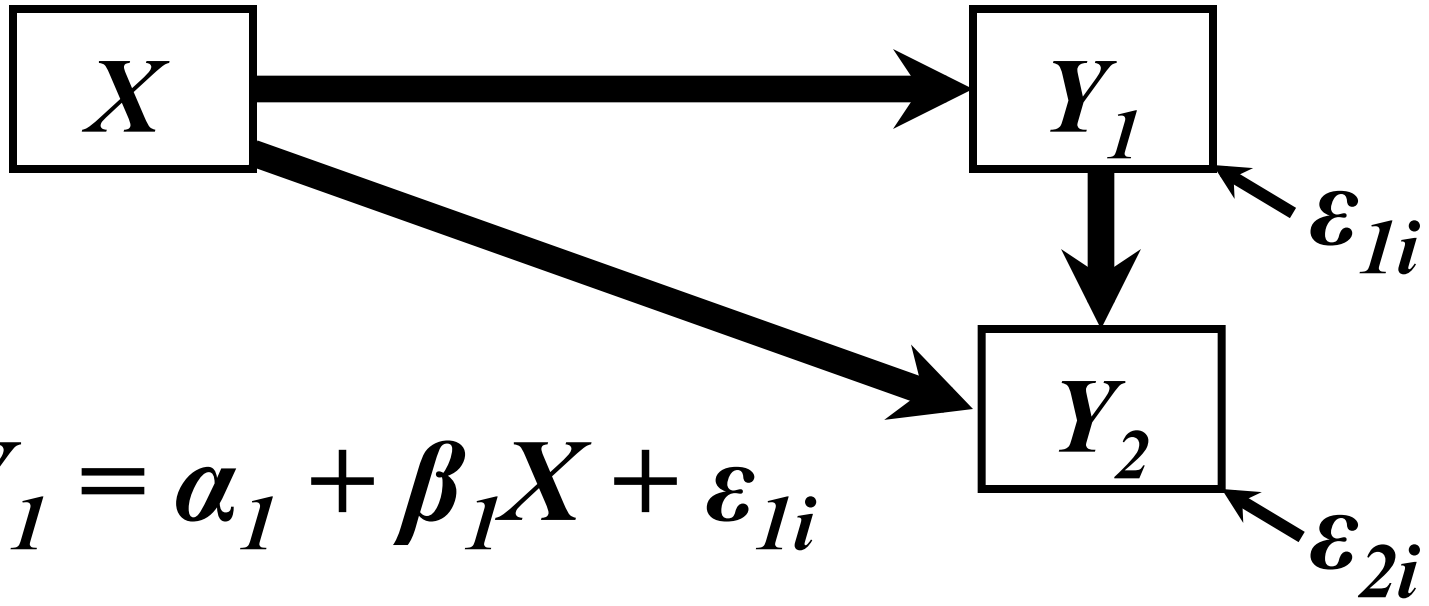
Origin of Structural Equation Modeling



Sewell Wright
1897-1988

1st paper in:
1920

The Wright Idea

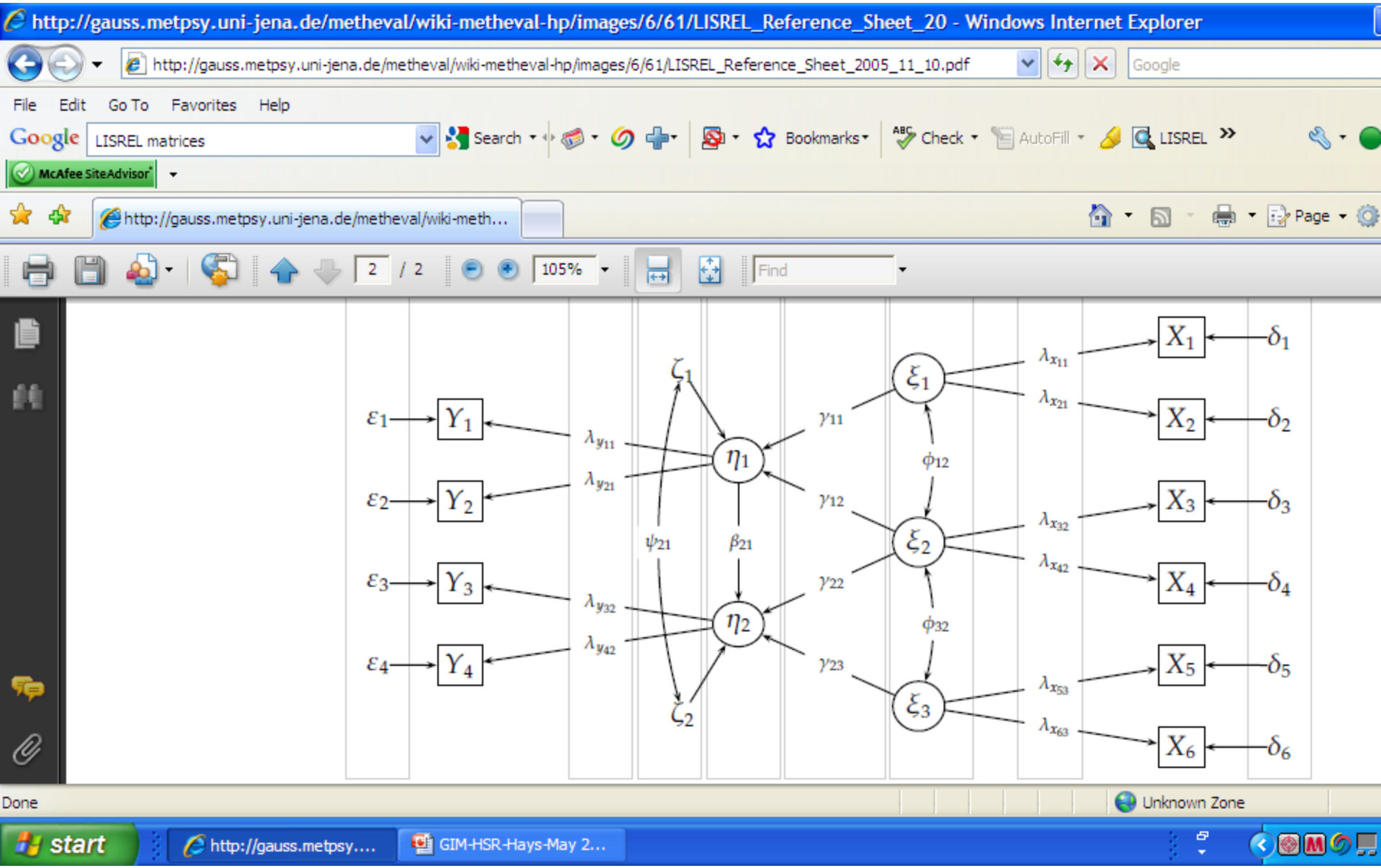


$$Y_1 = \alpha_1 + \beta_1 X + \varepsilon_{1i}$$

$$Y_2 = \alpha_2 + \beta_2 X + \beta_3 Y_1 + \varepsilon_{2i}$$

The LISREL Synthesis

Karl Jöreskog
1934 - present
Key Synthesis paper- 1973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File Edit Go To Favorites Help
LISREL matrices
Search
Bookmarks
Check
AutoFill
LISREL
McAfee SiteAdvisor
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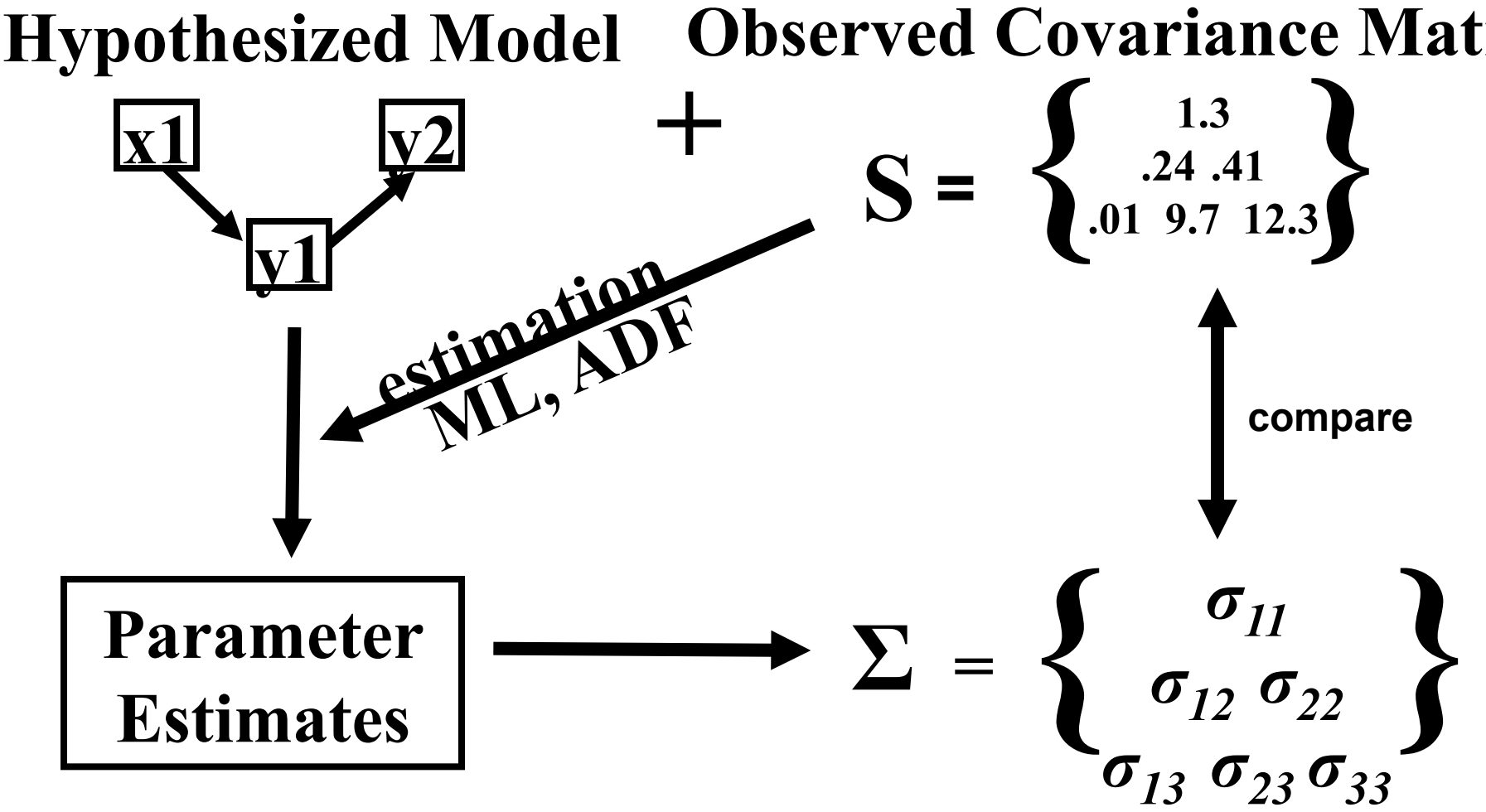
Page
2 / 2
105%
Find
ε_1 ε_2 ε_3 ε_4
Y_1 Y_2 Y_3 Y_4
λ_{y11} λ_{y21} λ_{y32} λ_{y42}
ζ_1 ζ_2
η_1 η_2
ψ_{21} β_{21}
γ_{11} γ_{12} γ_{22} γ_{23}
ξ_1 ξ_2 ξ_3
ϕ_{12} ϕ_{32}
λ_{x11} λ_{x21} λ_{x32} λ_{x42} λ_{x53} λ_{x63}
X_1 X_2 X_3 X_4 X_5 X_6
δ_1 δ_2 δ_3 δ_4 δ_5 δ_6
Done
Unknown Zone
start
http://gauss.metpsy....
GIM-HSR-Hays-May 2...

Evaluation of Model Fit



Fit Indices

- Normed fit index: $\frac{\chi^2_{null} - \chi^2_{model}}{\chi^2_{null}}$
- Non-normed fit index: $\frac{\frac{\chi^2_{null}}{df_{null}} - \frac{\chi^2_{model}}{df_{model}}}{\left(\frac{\chi^2_{null}}{df_{null}} - 1 \right)}$
- Comparative fit index: $1 - \left(\frac{\chi^2_{model} - df_{model}}{\chi^2_{null} - df_{null}} \right)$

Root Mean Square Error of Approximation (RMSEA)

- Lack of fit per degrees of freedom, controlling for sample size
  - $Q = (s - \sigma(\Theta))' W(s - \sigma(\Theta))$
  - SQR of $(Q/df) - (1/(N - G))$
- RMSEA < 0.06 are desirable

EQS 6.1 for Windows

Bentler, PM. (2006). EQS 6 Structural Equations Program Manual. Encino, CA: Multivariate Software, Inc.

$300 with UCLA discount

- Same as ACER Aspire One

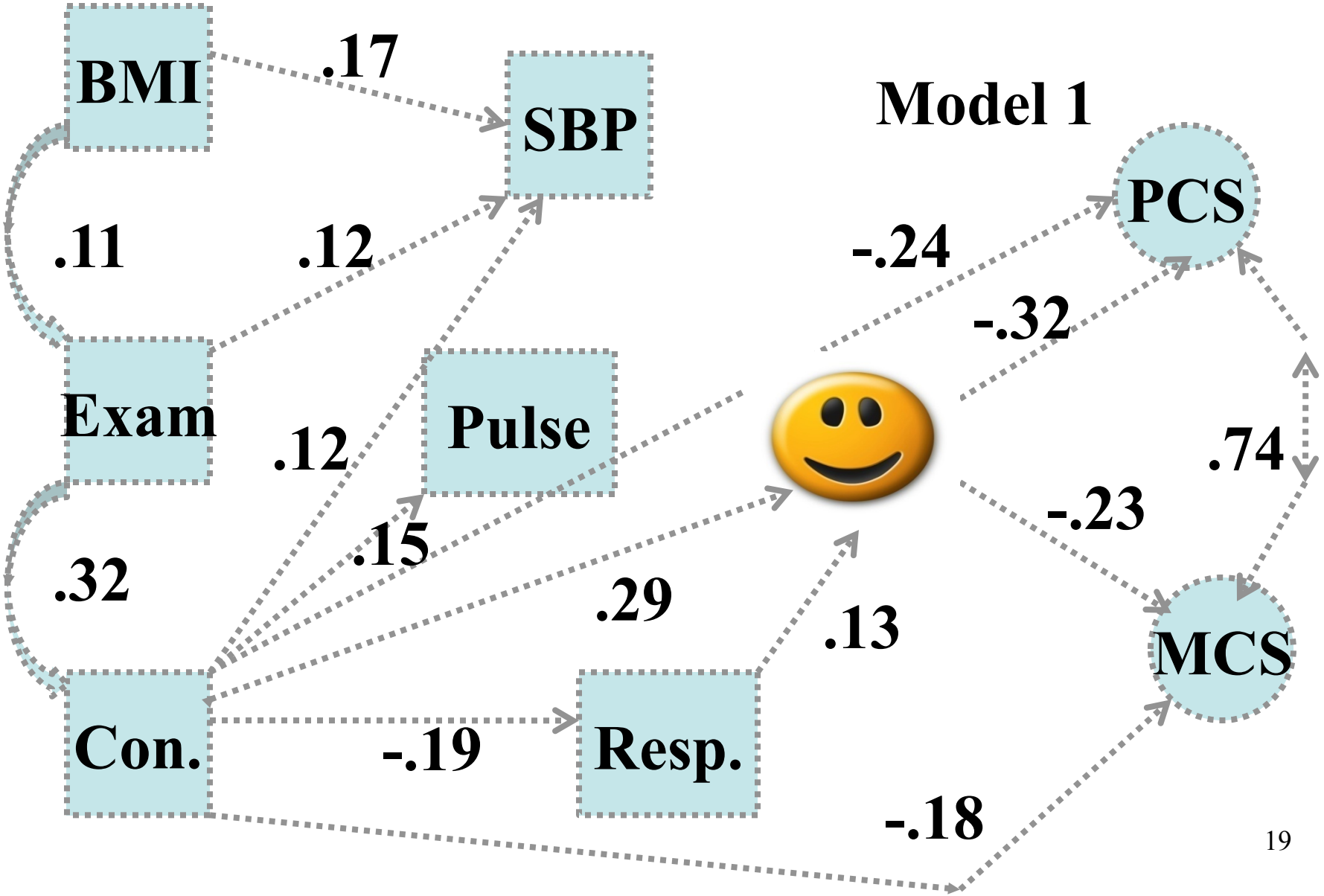
```
//TITLE
      Heslin #3 May 1 2009
/SPECIFICATIONS
VARIABLES=18; CASES=327;
DATAFILE='c:\heslin\heslinout2.txt'; ANALYSIS=COVARIANCE;MATRIX=RAW;
METHOD=ML,ROBUST;
/LABELS
V1=BMI;V2=EXAM_CT;V3=MEDHIST_CT;V4=SBP;V5=PULSE;V6=RESP;V7=ARSW1;
V8=ARSW2;V9=ARSW3;V10=ARSW4;V11=PF_T;V12=RP_T;V13=BP_T;V14=GH_T;
V15=EM_T;V16=RE_T;V17=SF_T;V18=EN_T;
F1=PCS;F2=MCS;F3=ARSW;
/EQUATIONS
V11=1*F1 + E11;
V12=1*F1 + E12;
V13=1*F1 + E13;
V14=1*F1 + 1*F2 + E14;
V15=1*F2 + E15;
V16=1*F2 + E16;
V17=1*F2 + 1*F1 + E17;
V18=1*F2 + E18;
V7=1*F3 + E7;
V8=1*F3 + E8;
V9=1*F3 + E9;
V10=1*F3 + E10;
V6=1*V3 + E6;
V5=1*V3 + E5;
V4=1*V1 + 1*V2 + 1*V3 + E4;
F1=1*F3 + 1*V3 + 1.000 D1;
F2=1*F3 + 1*V3 + 1.000 D2;
F3=1*V3 + 1*V6 + 1.000 D3;
/
```

```
/VARIANCES
V1 TO V3=10*;E4 TO E18=5*;D1=1;D2=1;D3=1;
/COVARIANCES
V1,V2=4*;V2,V3=4*;D1,D2=1*;E17,E16=1*;E16,E12=1*;
/TECHNICAL
ITR=200;
/LMTEST
 set=PVV,PFF,PVV,PEE,GFF,GFD,GFE;
```

Standardized Betas

General Case:	$b'_k = b_k * \frac{s_{x_k}}{s_y}$
Two IV case:	$b'_1 = \frac{r_{y1} - (r_{12} * r_{y2})}{1 - r_{12}^2}$ $b'_2 = \frac{r_{y2} - (r_{12} * r_{y1})}{1 - r_{12}^2}$
1 IV case	$b' = r_{yx}$

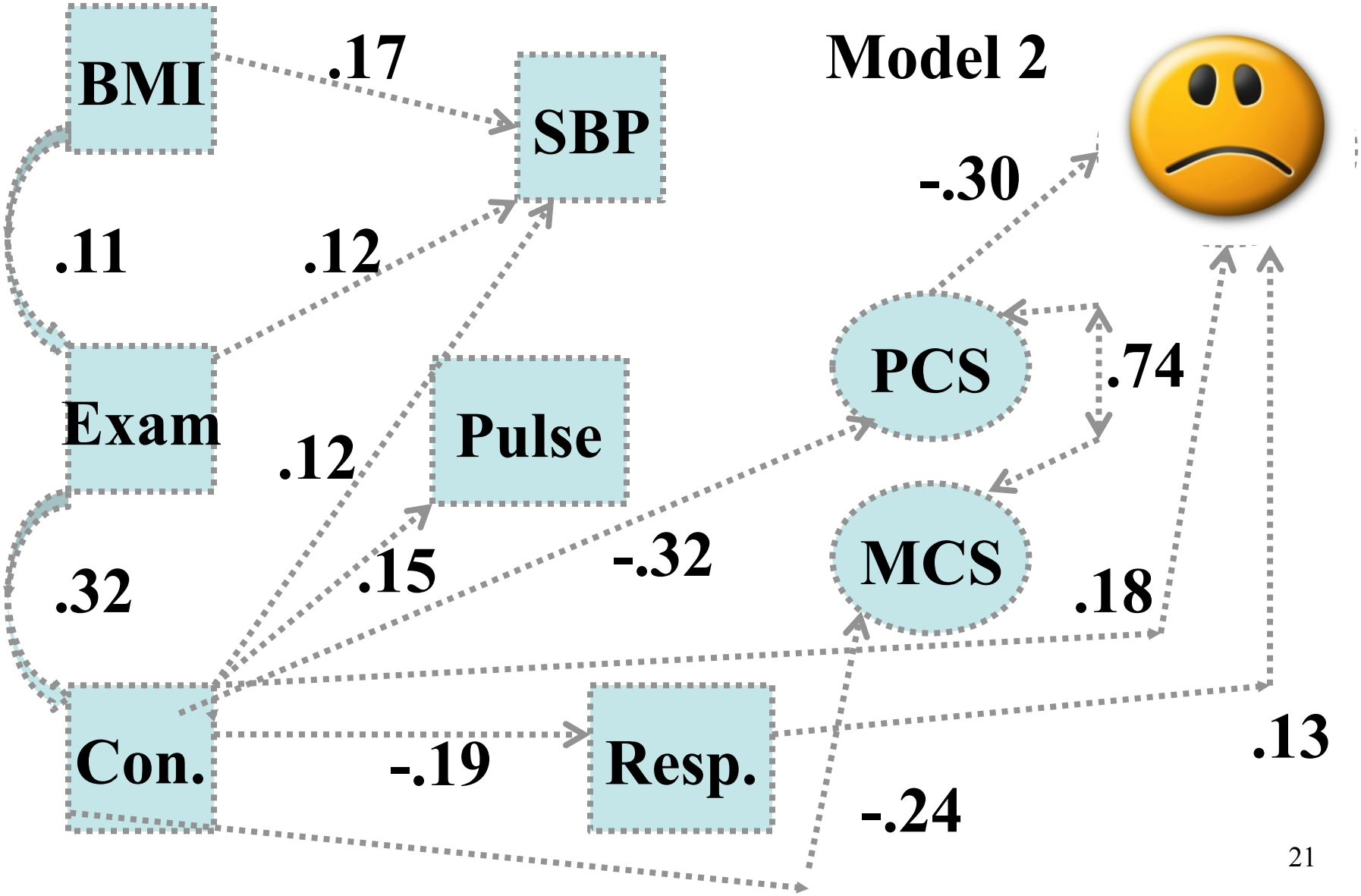
$\chi^2 = 264.81$ (df = 123); CFI = 0.945; RMSEA = 0.059



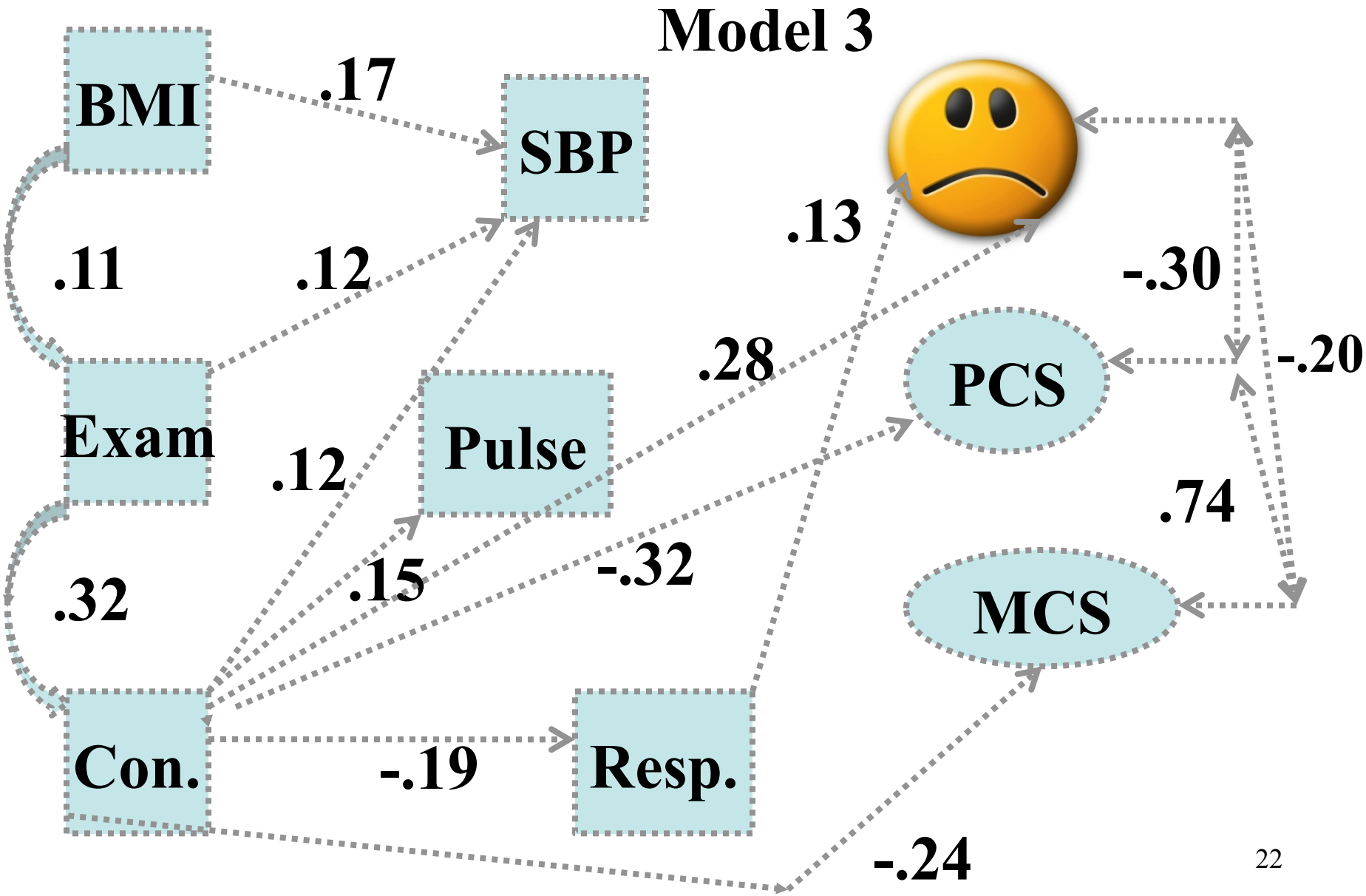
171-48 = 123 dfs

- 171 unique variances & covariances
  - 18 observed variables * (19/2) = 171
- 48 estimates in the model
  - 3 observed variable variances
  - 15 observed variable errors (uniqueness)
  - 2 correlations among observed variables
  - 2 correlations among uniqueness terms
  - 14 factor loadings
  - 11 structural paths
  - 1 correlation among residuals

$\chi^2 = 243.87$ (df = 123); CFI = 0.953; RMSEA = 0.055



$\chi^2 = 265.50$ (df = 123); CFI = 0.945; RMSEA = 0.060



Conclusions

- Stable
  - SBP ←BMI, Exam, Conditions
  - Pulse, Respiratory rate ← Conditions
  - ARSW ← Conditions, Respiratory rate
  - (Conditions has small – indirect effect)
  - PCS, MCS ← Conditions
- Instable
  - PCS, MCS ←ARSW
  - ARSW ←PCS

Acknowledgment of Support

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UCLA/DREW Project EXPORT, NCMHD, P20MD000148 and P20MD000182

Appendix: Identification

- Identification
  - “Every unmeasured variable in a structural model must have its scale determined. This can always be done by fixing a path from that variable to another variable at some known value (usually 1.0). An alternative method for determining the scale of an independent unmeasured variable is to fix its variance at some know value (usually 1.0).”

Appendix: Sample Size

- “The ratio of sample size to number of free parameters to be estimated may be able to go as low as 5:1 under normal and elliptical theory. Although there is little experience on which to base a recommendation, a ratio of at least 10:1 may be more appropriate for arbitrary distributions. These ratios needs to be larger to obtain trustworthy z-tests on the significance of parameters, and still larger to yield correct model evaluation chi-square probabilities.”