

Latent variable modeling: A practical guide

Applied Examples

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1.1-CFA-Fixed-Factor.inp

DATA: FILE = mydata.dat;

VARIABLE:

NAMES = SUP1 SUP2 SUP3;

MODEL:

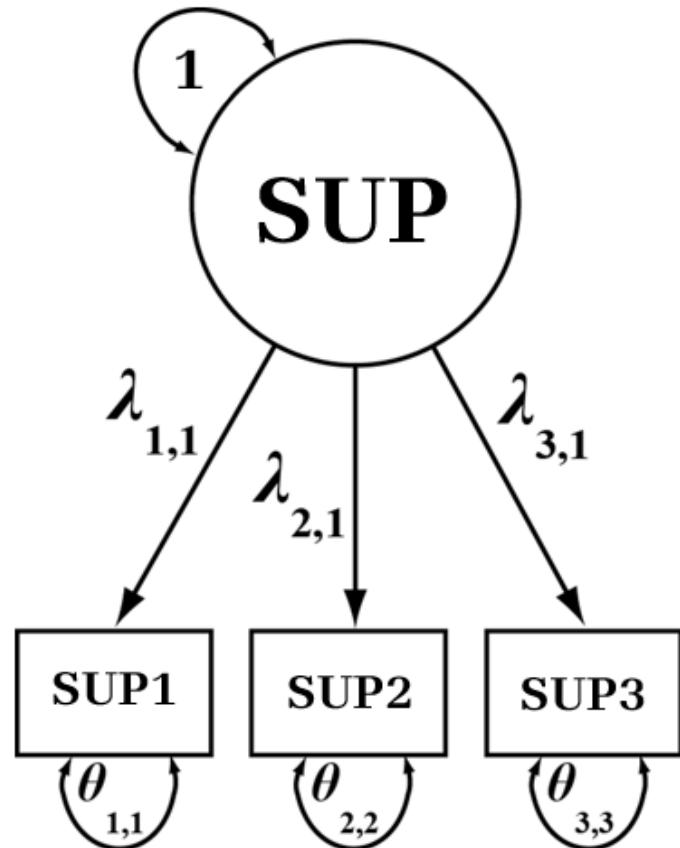
SUP by SUP1*

 SUP2

 SUP3;

SUP@1;

OUTPUT: TECH1;



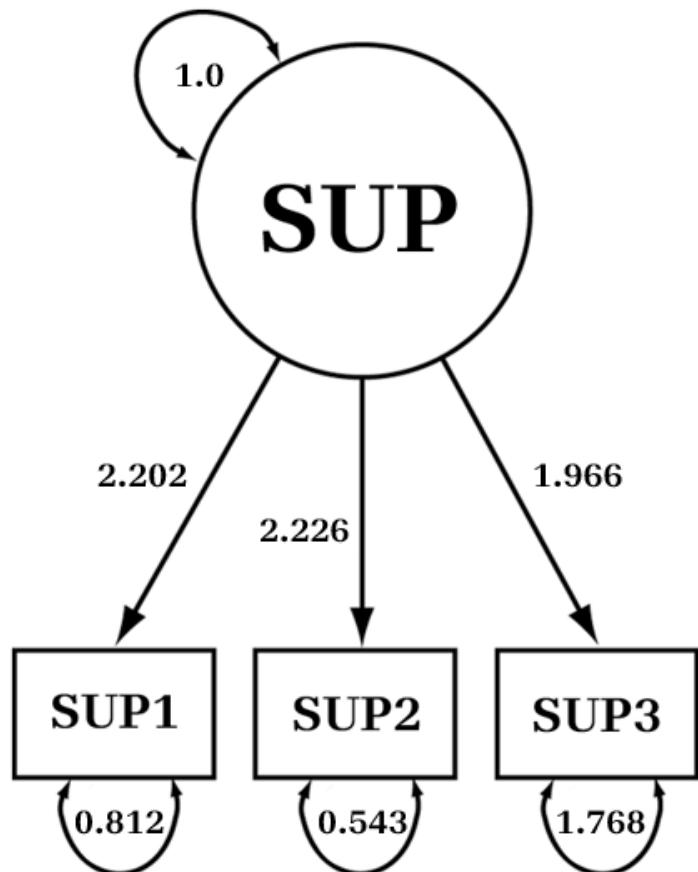
1.1-cfa-fixed-factor.out

MODEL RESULTS

		Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
SUP	BY				
	SUP1	2.202	0.155	14.246	0.000
	SUP2	2.226	0.150	14.879	0.000
	SUP3	1.966	0.164	11.990	0.000
Intercepts					
	SUP1	3.287	0.199	16.522	0.000
	SUP2	2.990	0.196	15.239	0.000
	SUP3	3.322	0.198	16.739	0.000
Variances					
	SUP	1.000	0.000	999.000	999.000
Residual Variances					
	SUP1	0.812	0.183	4.429	0.000
	SUP2	0.543	0.171	3.176	0.001
	SUP3	1.768	0.243	7.265	0.000

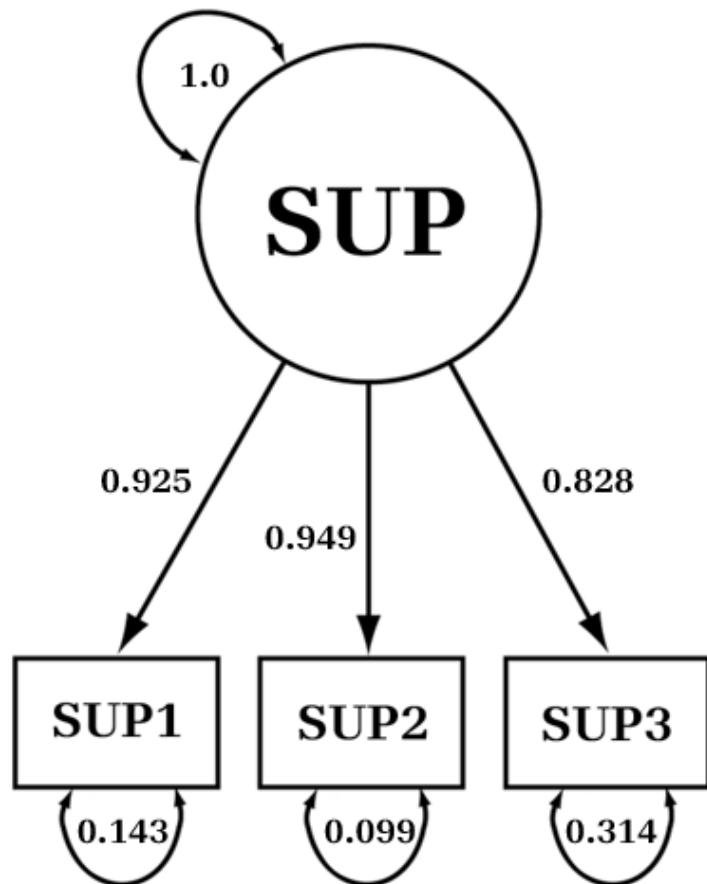
Unstandardized

	Estimate	S.E.	Est./S.E.	P-Value
SUP BY				
SUP1	2.202	0.155	14.246	0.000
SUP2	2.226	0.150	14.879	0.000
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SUP2	0.543	0.171	3.176	0.001
SUP3	1.768	0.243	7.265	0.000



STDYX Standardization

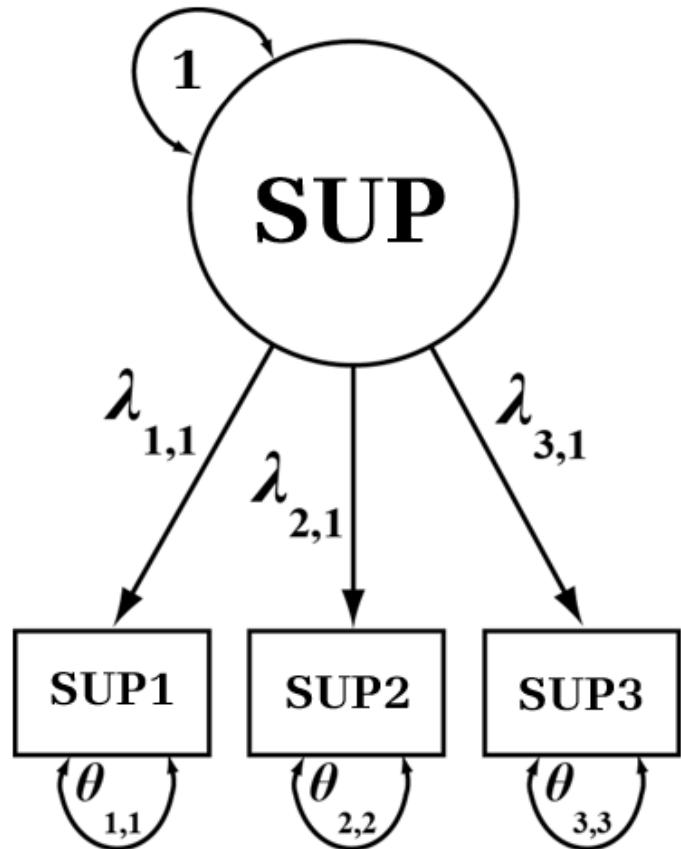
	Estimate	S.E.	Est./S.E.	P-Value
SUP BY				
SUP1	0.925	0.019	48.366	0.000
SUP2	0.949	0.017	54.928	0.000
SUP3	0.828	0.029	28.129	0.000
Intercepts				
SUP1	1.382	0.117	11.818	0.000
SUP2	1.275	0.113	11.318	0.000
SUP3	1.400	0.118	11.897	0.000
Variances				
SUP	1.000	0.000	999.000	999.000
Resid Var				
SUP1	0.143	0.035	4.050	0.000
SUP2	0.099	0.033	3.011	0.003
SUP3	0.314	0.049	6.435	0.000



Perceived Social Support (latent SUP) explains 85.6% of the variance in the indicator SUP1 ($0.925^2 = 0.856$). Additionally, the correlation for SUP1 and SUP2 is $(0.925 * 0.949) = 0.87$

cfa-examples.R (Lavaan)

```
library(lavaan)  
  
m1 <- '  
SUP =~ NA*SUP1 + SUP2 + SUP3  
SUP ~~ 1*SUP  
  
'  
  
fit1 <- cfa(m1, data=mydata,  
std.lv=T)  
  
summary(fit1, standardized=T,  
fit.measures=T, rsquare=T)
```



Sample CFA Lavaan Estimates

Latent Variables:

	Estimate	Std. Err	z-value	P(> z)	std.lv	std.all
SUP =~						
SUP1	2.211	0.155	14.262	0.000	2.211	0.927
SUP2	2.230	0.150	14.821	0.000	2.230	0.949
SUP3	1.978	0.164	12.039	0.000	1.978	0.832

Variances:

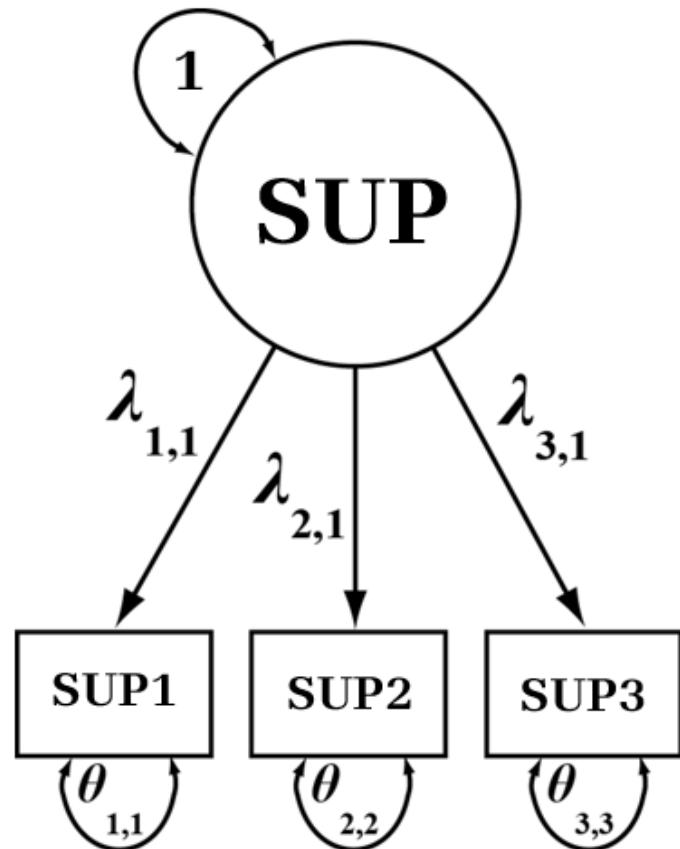
	Estimate	Std. Err	z-value	P(> z)	std.lv	std.all
SUP	1.000				1.000	1.000
.SUP1	0.797	0.180	4.419	0.000	0.797	0.140
.SUP2	0.554	0.170	3.268	0.001	0.554	0.100
.SUP3	1.739	0.240	7.240	0.000	1.739	0.308

R-Square:

	Estimate
SUP1	0.860
SUP2	0.900
SUP3	0.692

1.1-CFA-Fixed-Factor.sas (Proc Calis)

```
proc calis data=mydata method=ml;  
path SUP → SUP1 SUP2 SUP3 = ly1 - ly3;  
pvar SUP = 1,  
SUP1 SUP2 SUP3 = te1 - te3;  
run;
```



Sample CFA Proc Calis Estimates

The SAS System						
The CALIS Procedure Covariance Structure Analysis: Maximum Likelihood Estimation						
PATH List						
Path	Parameter	Estimate	Standard Error	t Value	Pr > t	
SUP ==> SUP1	ly1	2.21910	0.15615	14.2114	<.0001	
SUP ==> SUP2	ly2	2.23813	0.15155	14.7684	<.0001	
SUP ==> SUP3	ly3	1.98466	0.16544	11.9962	<.0001	

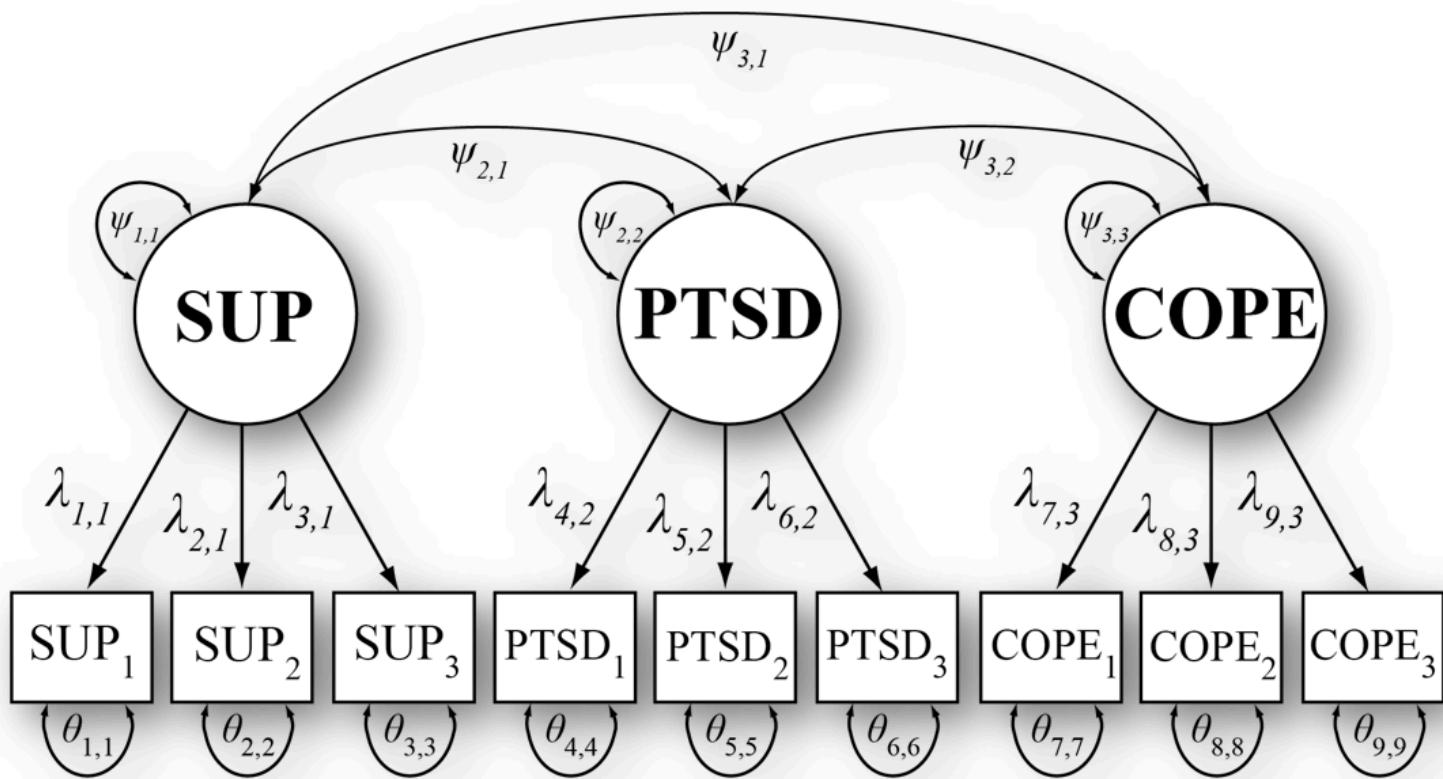
Variance Parameters						
Variance Type	Variable	Parameter	Estimate	Standard Error	t Value	Pr > t
Exogenous	SUP		1.00000			
Error	SUP1	theta1	0.80308	0.18240	4.4030	<.0001
	SUP2	theta2	0.56811	0.17139	3.2563	0.0011
	SUP3	theta3	1.75168	0.24281	7.2143	<.0001

Squared Multiple Correlations			
Variable	Error Variance	Total Variance	R-Square
SUP1	0.80308	5.72750	0.8598
SUP2	0.56811	5.56733	0.8998
SUP3	1.75168	5.69054	0.6922

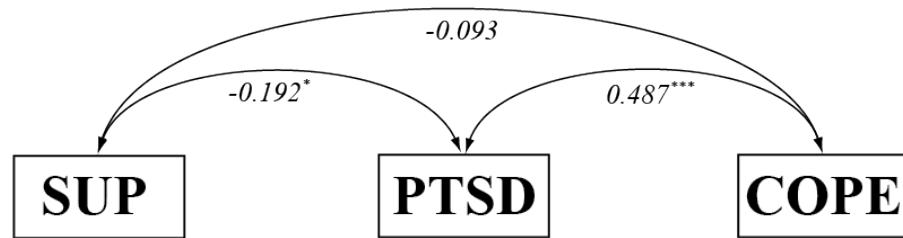
The SAS System						
The CALIS Procedure Covariance Structure Analysis: Maximum Likelihood Estimation						
Standardized Results for PATH List						
Path	Parameter	Estimate	Standard Error	t Value	Pr > t	
SUP ==> SUP1	ly1	0.92725	0.01879	49.3364	<.0001	
SUP ==> SUP2	ly2	0.94855	0.01718	55.2264	<.0001	
SUP ==> SUP3	ly3	0.83197	0.02905	28.6353	<.0001	

Standardized Results for Variance Parameters						
Variance Type	Variable	Parameter	Estimate	Standard Error	t Value	Pr > t
Exogenous	SUP		1.00000			
Error	SUP1	theta1	0.14022	0.03485	4.0229	<.0001
	SUP2	theta2	0.10025	0.03258	3.0766	0.0021
	SUP3	theta3	0.30782	0.04834	6.3673	<.0001

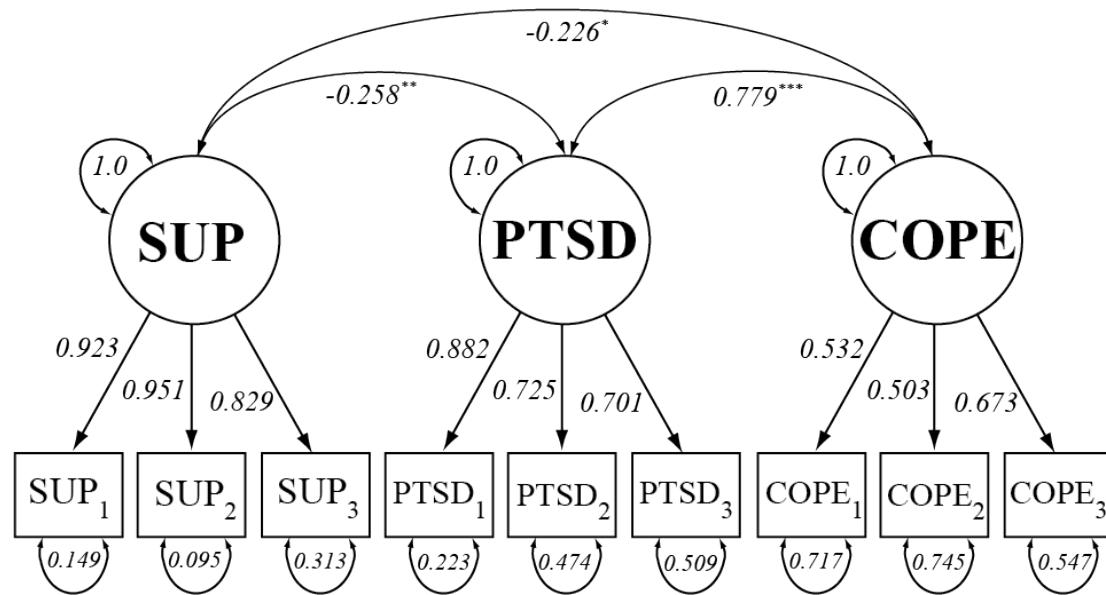
Observed vs. Latent Correlations.

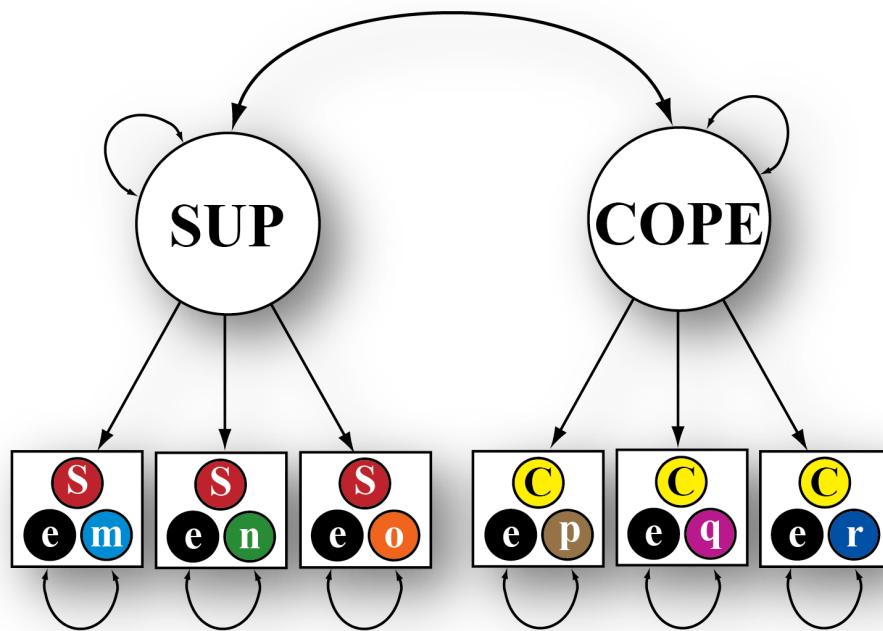
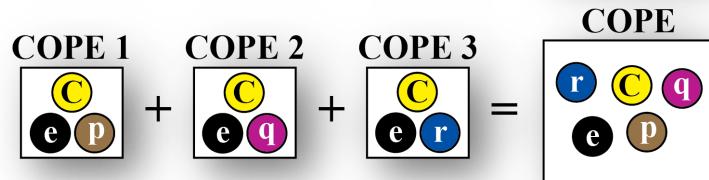
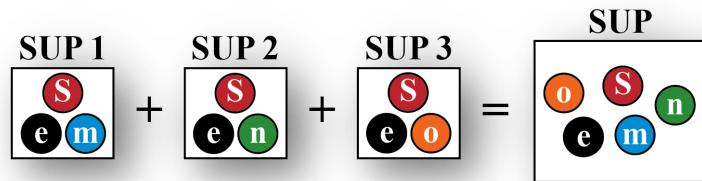


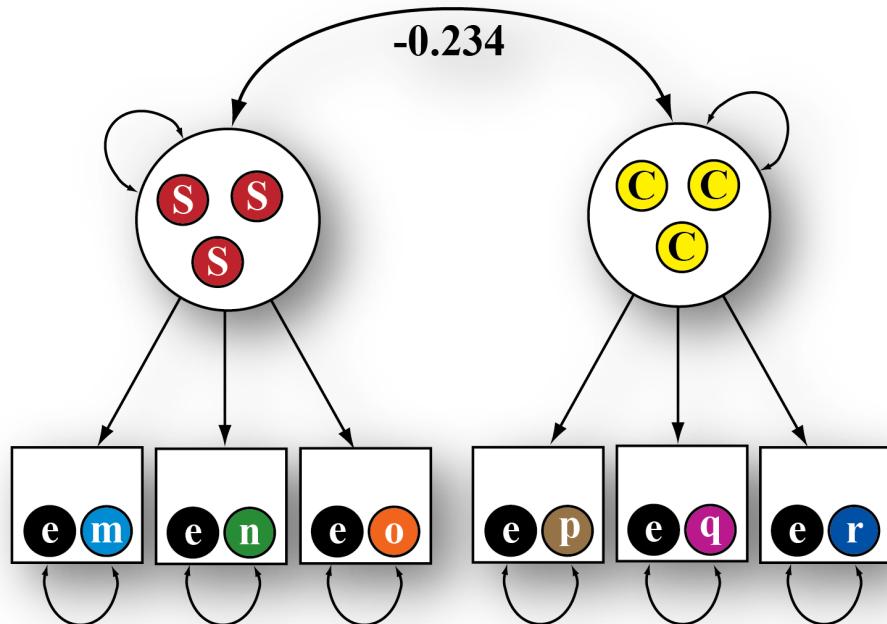
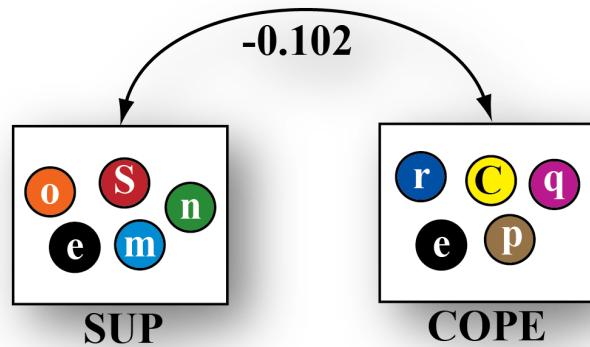
2.1-manifest-correlations.inp



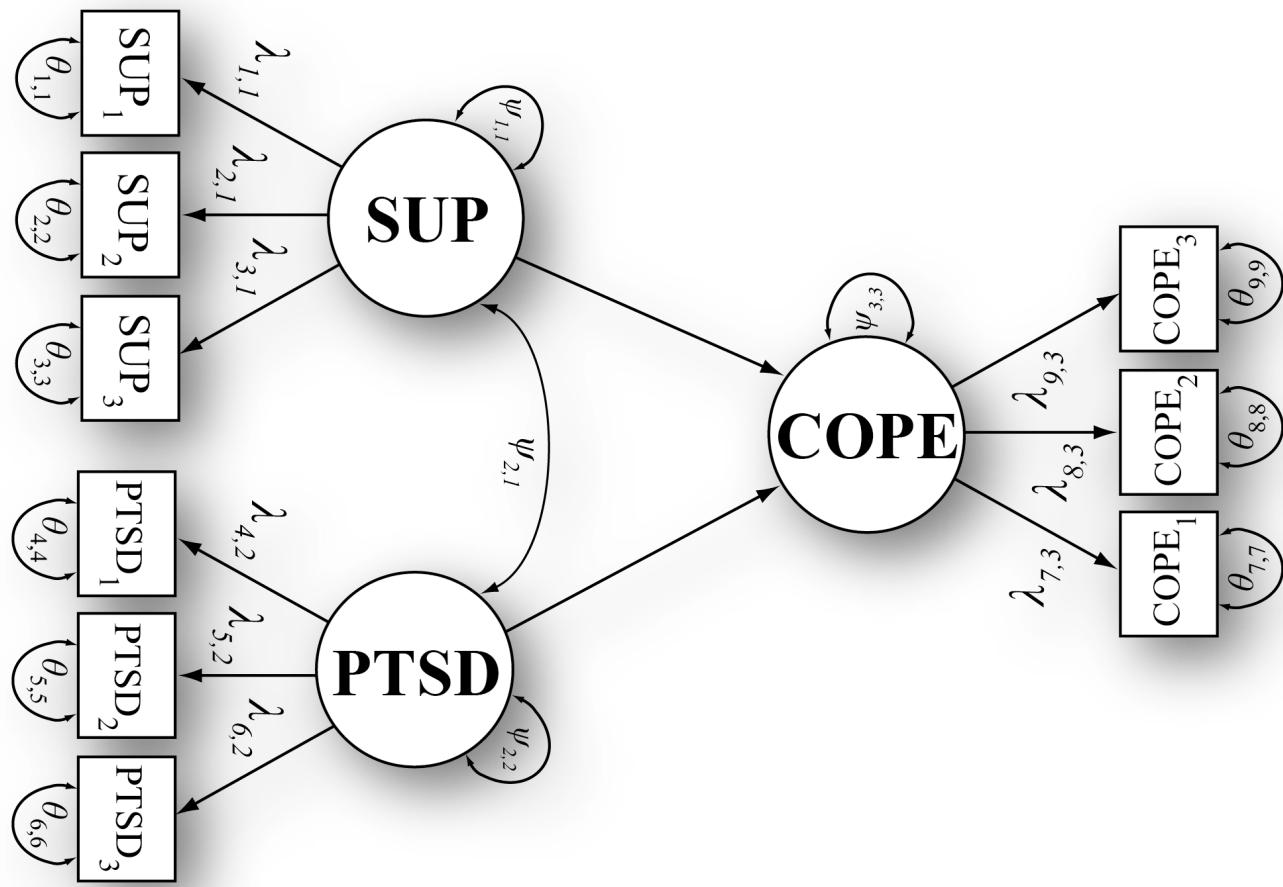
2.2-latent-correlations.inp



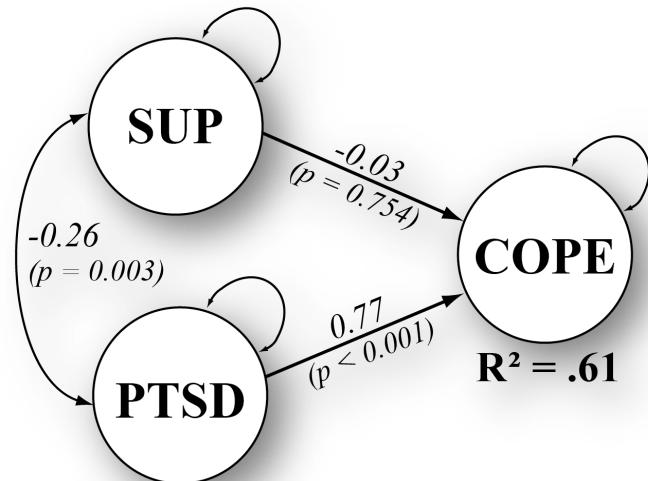
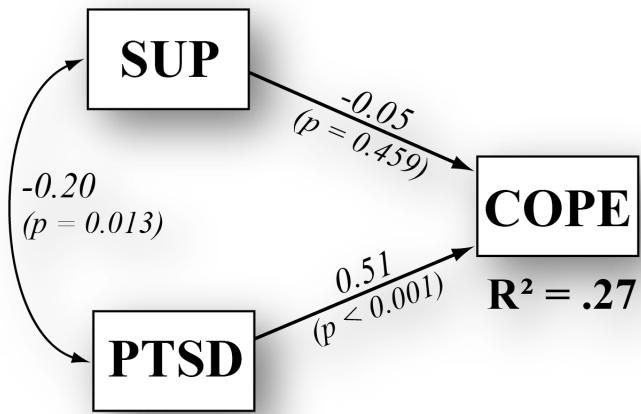




Structural Equation Modeling



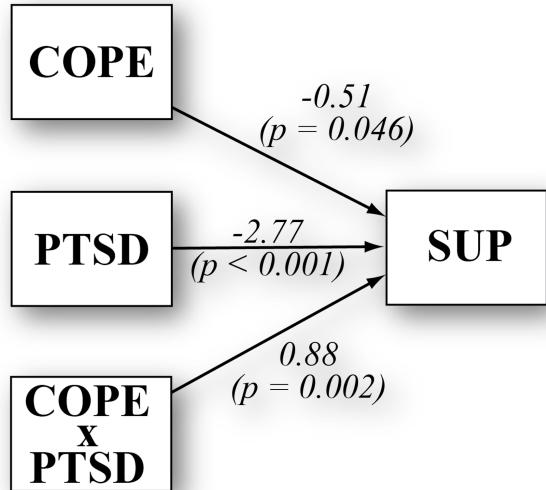
Latent vs. Manifest/Observed



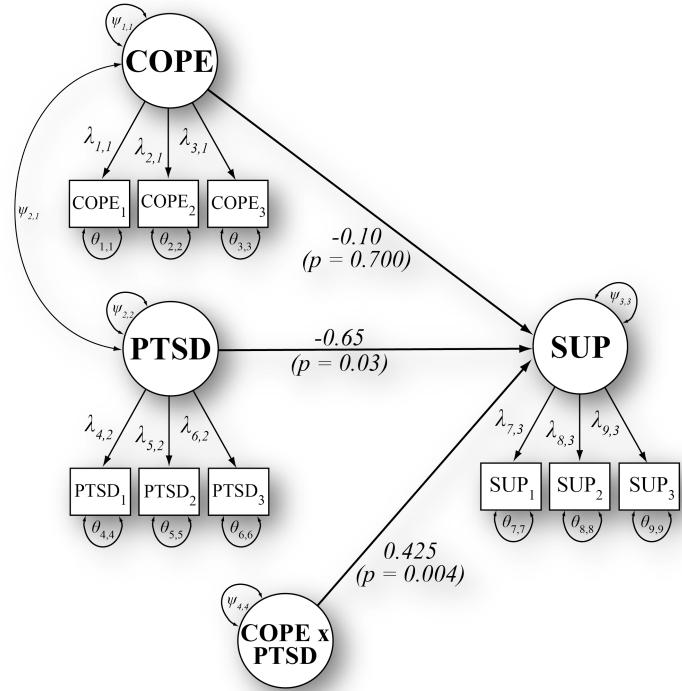
Measurement error in the observed variables can reduce the accuracy of the regression model.

Model Fit: $\chi^2(24, n = 144) = 36.14$; RMSEA = .059 (.000; .097); CFI = .980; TLI = .970

Manifest ($R^2 = 0.11$)

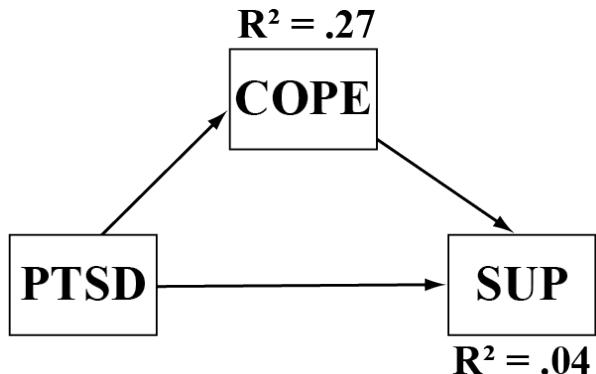


Latent ($R^2 = 0.46$)

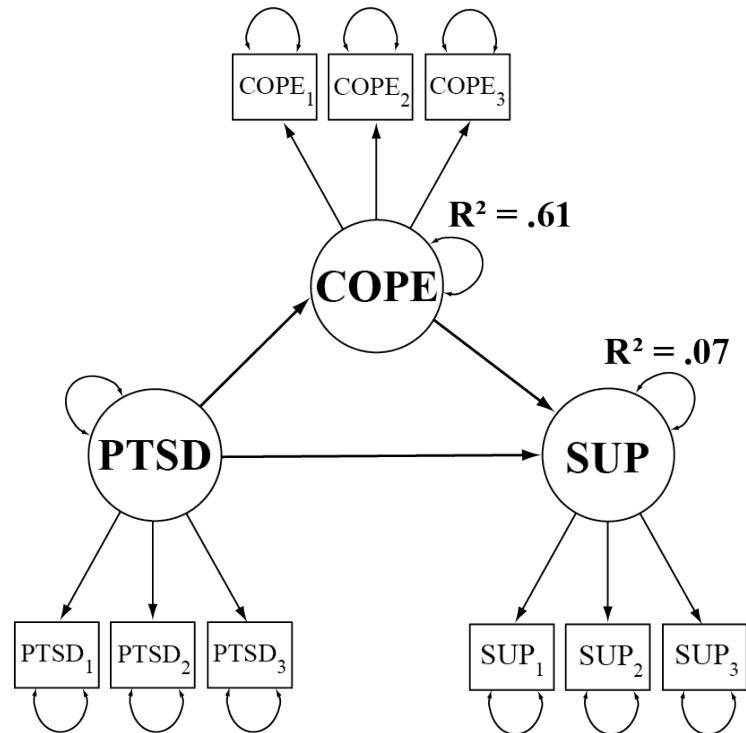


PTSD severity is a relatively modest / key determinant in whether coping strategies help or hinder social support.

Manifest $ab = -0.10 [-0.37, 0.18]$



Latent $ab = -0.05 [-0.64, 0.54]$



While this might seem less desirable, SEM accounts for measurement error, which can lead to more realistic estimates.

Power Analysis: Model Parameters

TITLE: Monte Carlo Simulation for Power;

MONTECARLO:

```
NAMES ARE sup1 sup2 sup3 cope1 cope2 cope3;
NOBSERVATIONS = 150;
NREPS = 2000;
SEED = 461981;
!save = mypower.dat;
```

MODEL POPULATION:

```
SUP BY sup1*0.924 sup2*0.953 sup3*0.832;
COPE BY cope1*0.532 cope2*0.505 cope3*0.675;
!SUP WITH COPE*-0.234;
SUP WITH COPE*-0.300;
sup1*0.146 sup2*0.093 sup3*0.308;
cope1*0.717 cope2*0.745 cope3*0.545;
SUP@1; COPE@1;
```

MODEL:

```
SUP BY sup1*0.924 sup2*0.953 sup3*0.832;
COPE BY cope1*0.532 cope2*0.505 cope3*0.675;
!SUP WITH COPE*-0.234;
SUP WITH COPE*-0.300;
sup1*0.146 sup2*0.093 sup3*0.308;
cope1*0.717 cope2*0.745 cope3*0.545;
SUP@1; COPE@1;
```

ANALYSIS: ESTIMATOR = ML;
OUTPUT: TECH9;

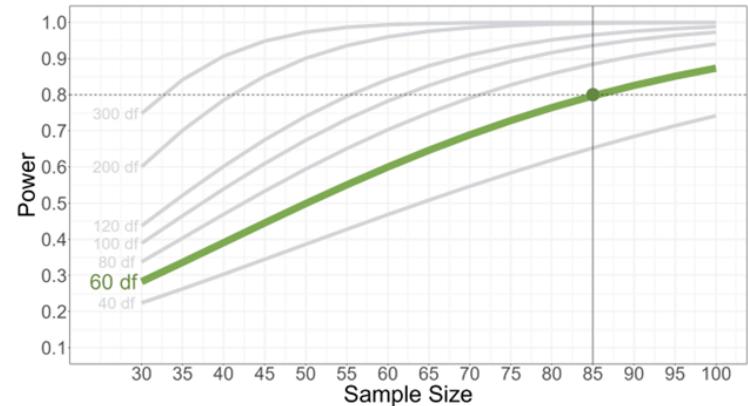
MODEL RESULTS

			Population	ESTIMATES	95%	% Sig
				Average	Cover	Coeff
SUP	BY					
SUP1			0.924	0.9203	0.955	1.000
SUP2			0.953	0.9491	0.945	1.000
SUP3			0.832	0.8293	0.957	1.000
COPE	BY					
COPE1			0.532	0.5300	0.944	0.995
COPE2			0.505	0.4991	0.949	0.993
COPE3			0.675	0.6837	0.952	0.997
SUP	WITH					
COPE			-0.300	-0.2928	0.940	0.797

80% power for a correlation of at least -0.30 given $N= 150$.

Power Analysis: Model Fit

```
w = NULL # we want to store results in here  
  
alpha = .05  
d.list = c(40, 60, 80, 100, 120, 200, 300) #degrees of freedom  
n.list = c(seq(30, 100, by = 5)) #sample size  
rmsea0 <- 0.05 #null hypothesized RMSEA (.05 close fit, .00 exact fit)  
rmseaaa.list = c(.10)  
  
for (d in d.list){  
  for (n in n.list){  
    for (rmsea in rmseaaa.list){  
  
      ncp0 <- (n-1)*d*rmsea0^2  
      ncpa <- (n-1)*d*rmseaaa^2  
  
      #compute power  
      if(rmseaa<rmseaaa){  
        cval <- qchisq(alpha,d,ncp=ncp0,lower.tail=F)  
        pow <- pchisq(cval,d,ncp=ncpa,lower.tail=F)  
      }  
      if(rmseaa>rmsea0){  
        cval <- qchisq(1-alpha,d,ncp=ncp0,lower.tail=F)  
        pow <- 1-pchisq(cval,d,ncp=ncpa,lower.tail=F)  
      }  
  
      w = rbind(w, c(d, n, rmseaaa, pow))  
  
      colnames(w) = c('df', 'n', 'rmseaaa', 'Power')  
      simdf <- as.data.frame(w)  
      simdf$grp <- as.factor(simdf$df)  
  
    }  
  }  
}
```



80% power for a CFA with at least 60 df given $N = 85$.

Thank you for participating!

Next Steps:

- Apply SEM concepts in practice
- Explore advanced topics (e.g., multi-group SEM, longitudinal SEM)
- Stay engaged—join SEM communities & discussions

Questions? Let's stay connected!