

# OpenMx Scripting

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Michael C. Neale, Hermine H. Maes, Meike Bartels

# What is OpenMx

- A free, full-featured, open source SEM package
- Runs on Windows, Mac OS-X, and Linux
- Runs inside the R statistical programming environment
- Funded by the NIH Roadmap Initiative

# OpenMx Features

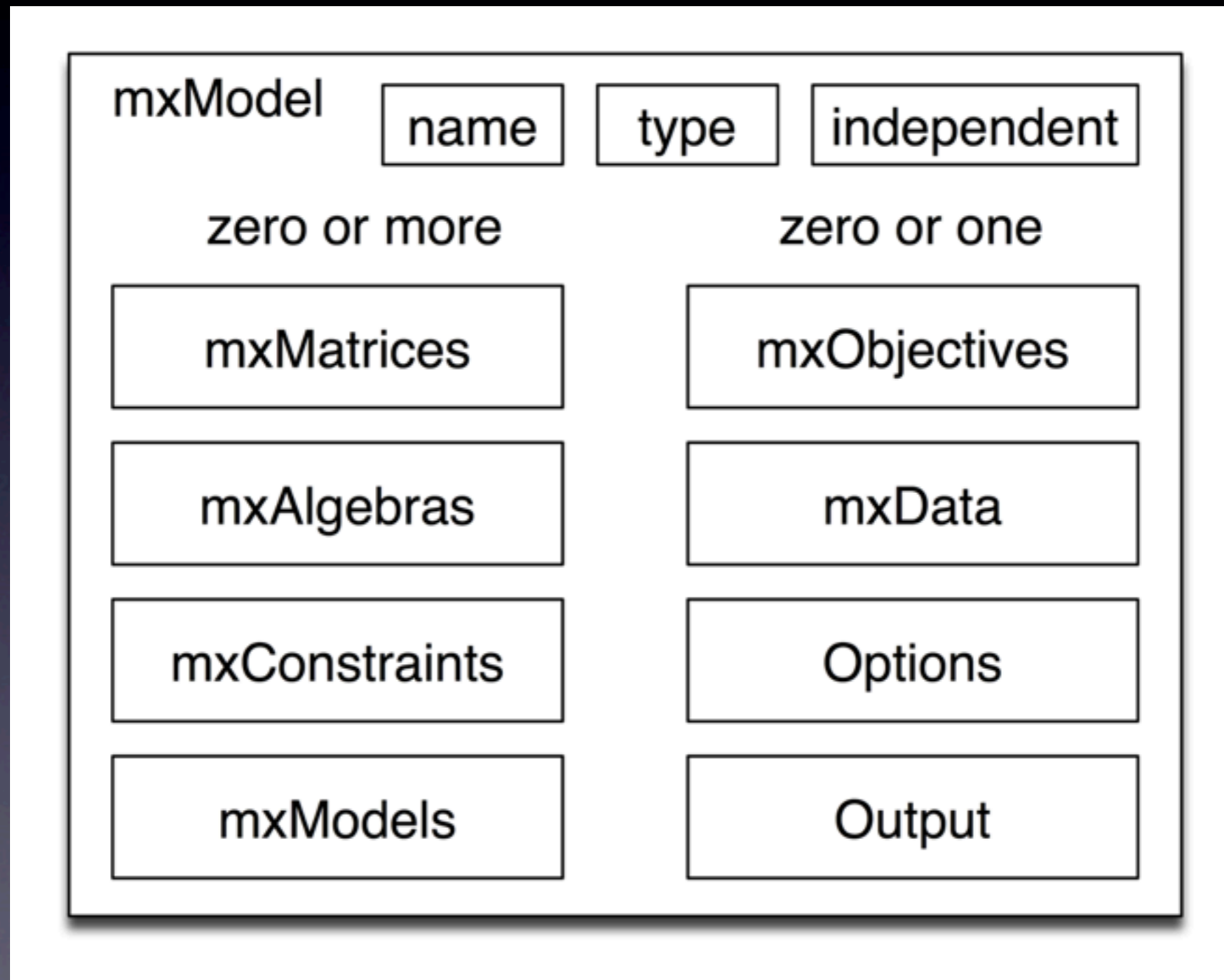
- A new approach to model specification
- Allows both path-style and matrix-style scripting
- Flexible optimization including nonlinear constraints
- Web-based forums, tutorials, and a wiki
- Support for most popular types of modeling
- Advanced features not found in other SEM packages
- An active development team.



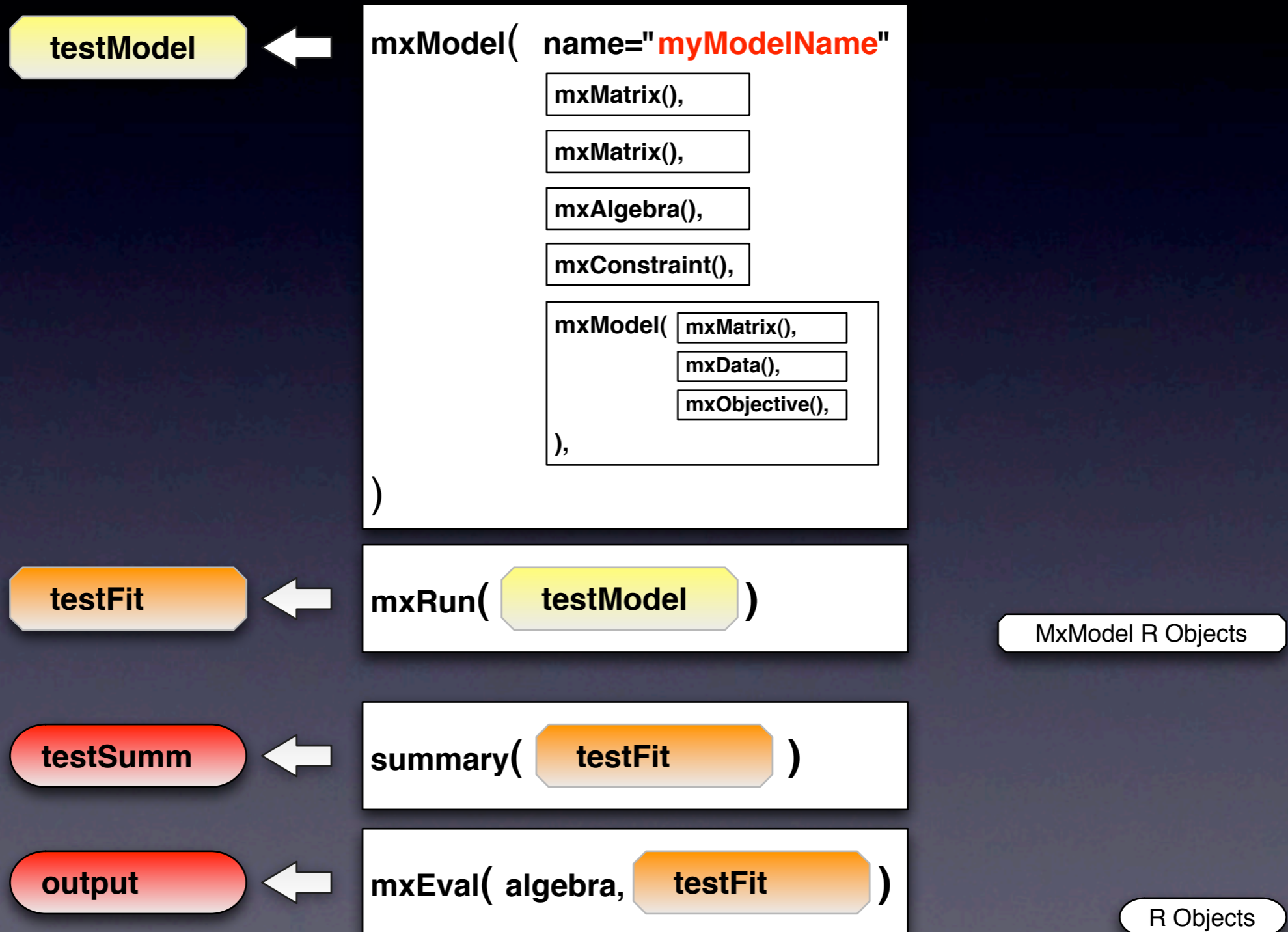
# OpenMx Models

- Multivariate Normal Structural Equation Models
- Multigroup Models, e.g. Behavior Genetic
- Full Information Maximum Likelihood
- Mixed Effects and Multilevel
- Multivariate Categorical Data with Thresholds
- Dynamical Systems Models
- Nonlinear Constraints
- User-supplied Matrix Algebra, Objective Functions

# OpenMx Commands



# OpenMx Process





# Univariate Model

## Raw Data -Matrix-Style

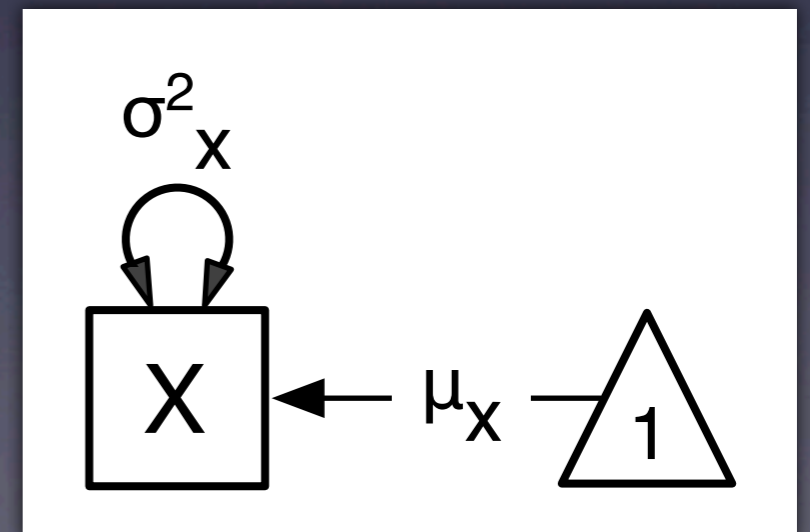
#example: Model to estimate means/ variances

#-----

```
require(OpenMx)
```

```
univModel <- mxModel("univ",  
  mxMatrix( type="Symm", nrow=1, ncol=1, free=T,  
    values=1, name="expCov" ),  
  mxMatrix( type="Full", nrow=1, ncol=1, free=T,  
    values=0, name="expMean" ),  
  mxData( observed=testData, type="raw" ),  
  mxFIMLObjective(  
    covariance="expCov",  
    means="expMean",  
    dimnames=selVars )  
)
```

```
univFit <- mxRun(univModel)
```



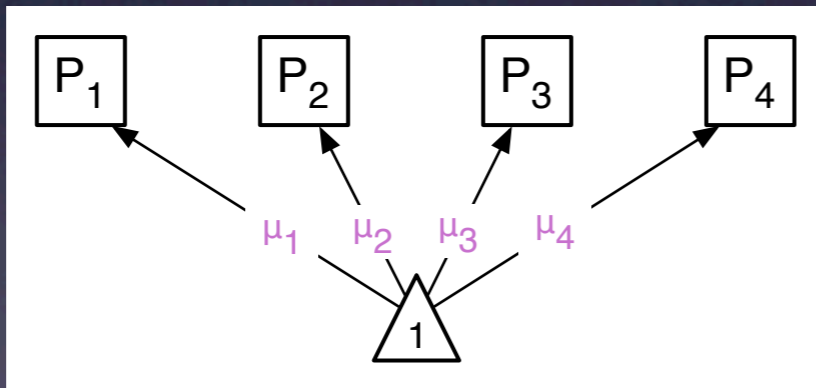
# Multivariate Model

## Multi-Group

```
manifestVars <-("mo3t1", "mo7t1", "mo10t1", "mo12t1"..)
nv <- 4      # number of variables
factorModel <- mxModel("factor",
  mxModel("All", ....),
  # parameters in mxMatrices, mxAlgebras
  mxModel("MZM", ....),
  # mxData, definition variables, mxObjective
  mxModel("DZM", ....),
  mxModel("MZF", ....),
  mxModel("DZF", ....),
  mxModel("DZO", ....)
)
```

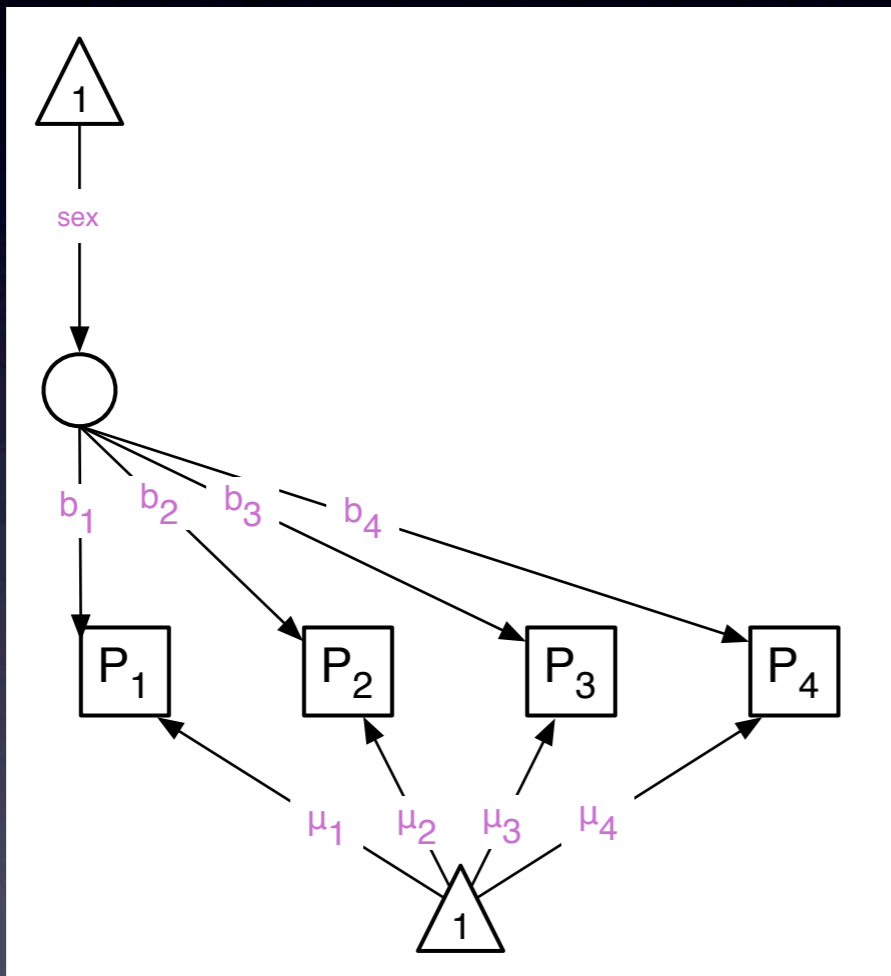


# Means



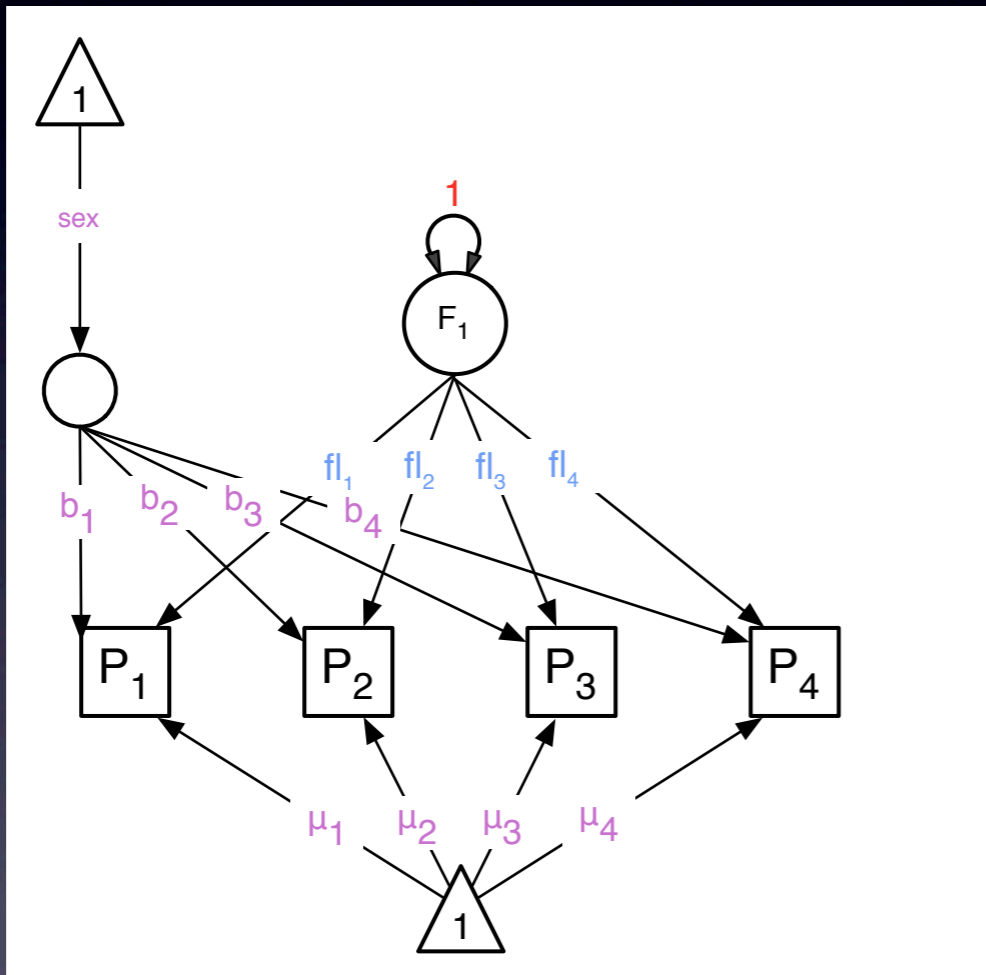
```
mxMatrix(  
  type="Full",  
  nrow=1,  
  ncol=nv,  
  free=TRUE,  
  values=0,  
  labels=c(  
    "meanm3", "meanm7",  
    "meanm10", "meanm12"),  
  name="Mean"),
```

# Regression on Sex



```
mxMatrix(  
  type="Full",  
  nrow=1,  
  ncol=nv,  
  free=TRUE,  
  values=0.1,  
  labels=c(  
    "beta1", "beta2",  
    "beta3", "beta4"),  
  name="Beta"),
```

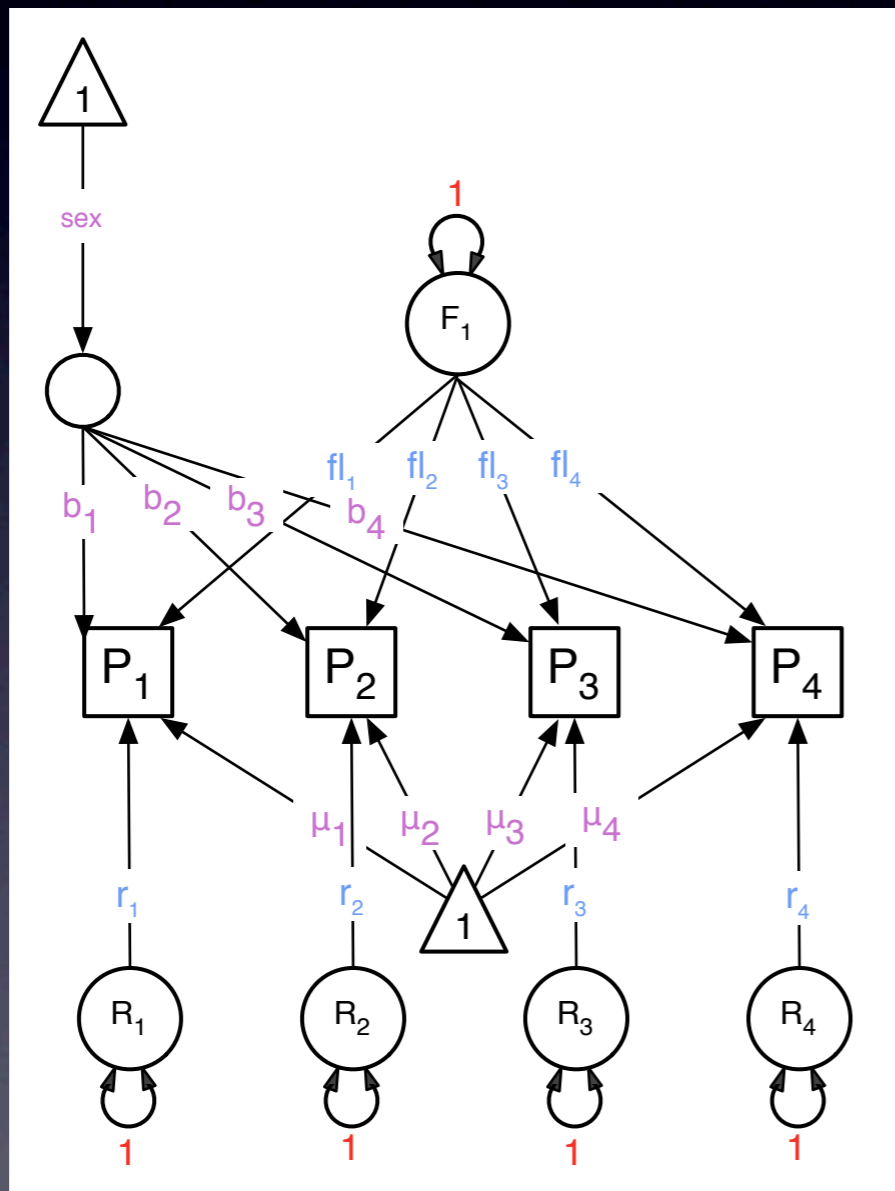
# Factor Loadings



```
mxMatrix(  
  type="Full",  
  nrow=nv,  
  ncol=1,  
  free=TRUE,  
  values=1.5,  
  name="facL"),
```

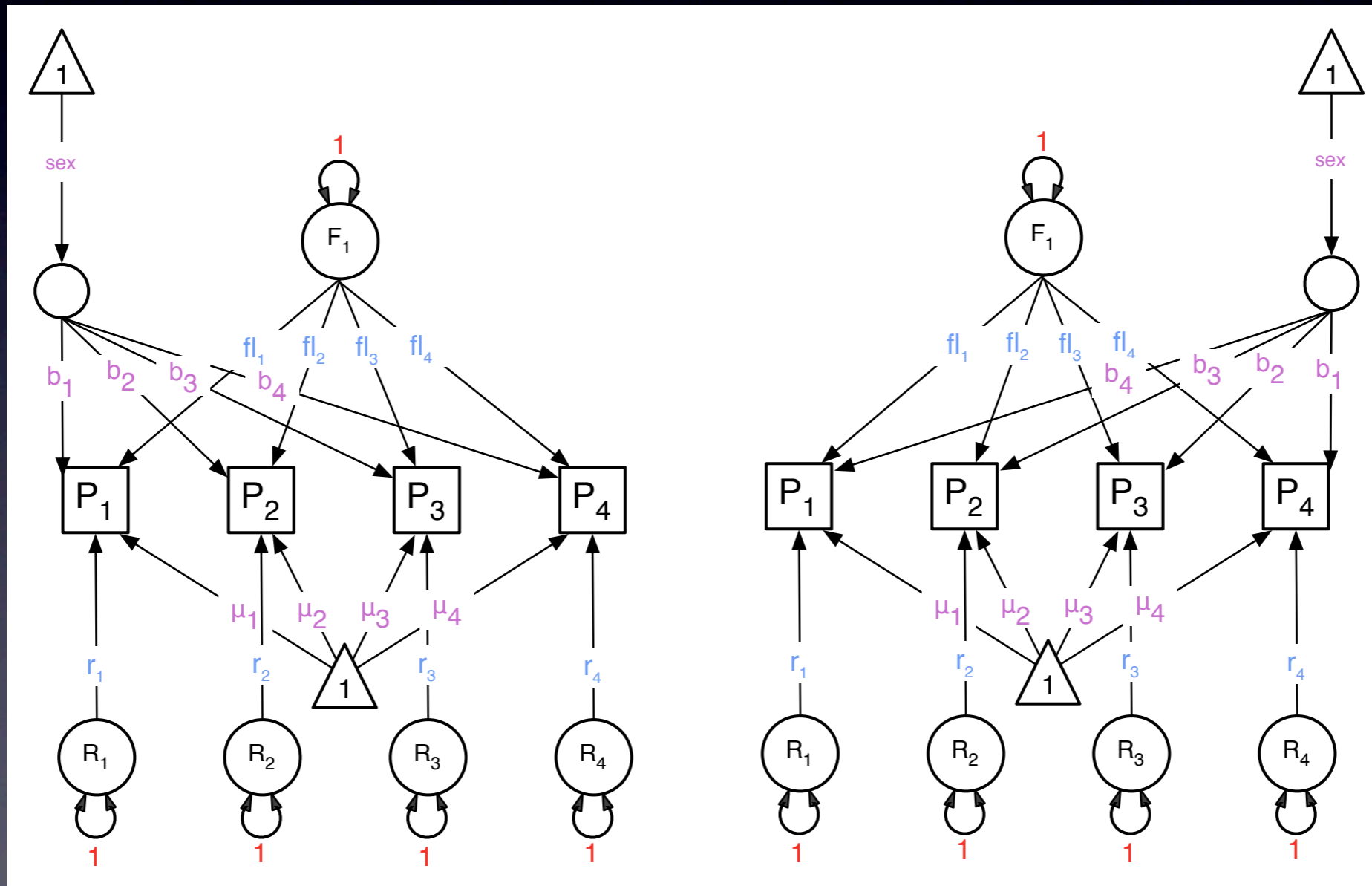


# Residuals



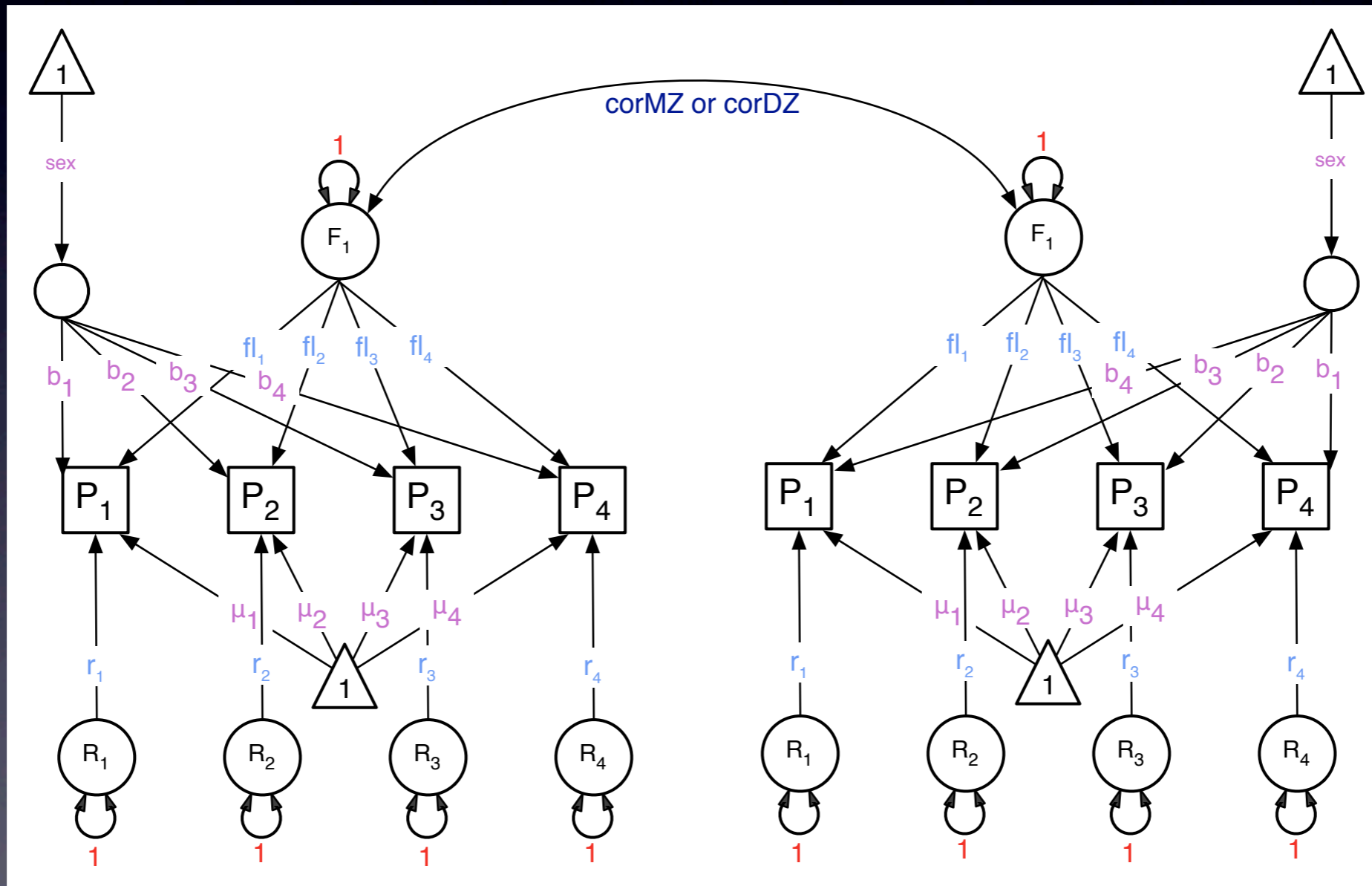
```
mxMatrix(  
  type="Diag",  
  nrow=nv,  
  ncol=nv,  
  free=TRUE,  
  values=2,  
  name="res"),
```

# Data from Twins



# Factor Correlations

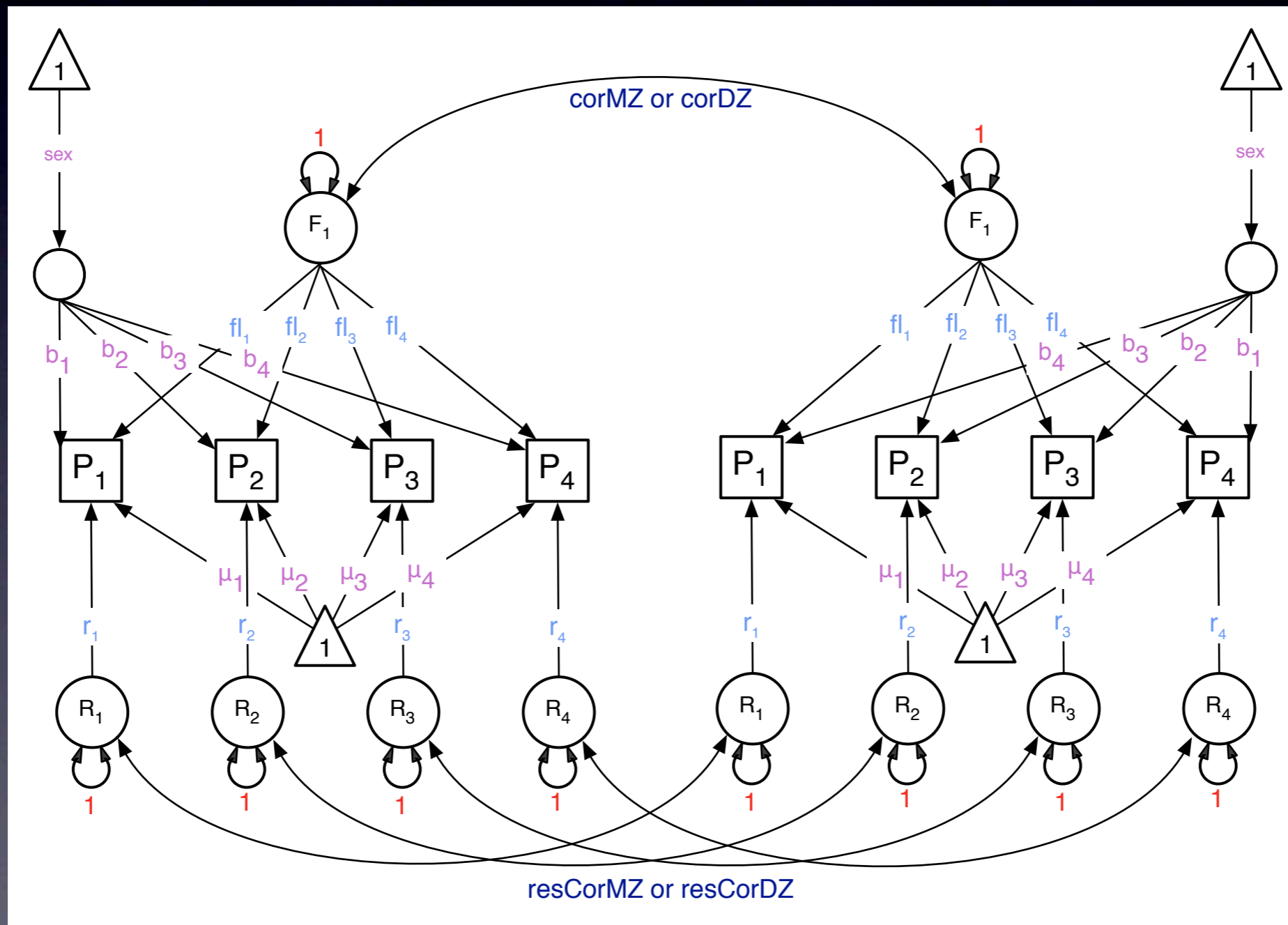
```
mxMatrix( type="Full", nrow=1, ncol=1, free=T,  
          values=.6, labels="corMZ", name="facCorMZ"),
```





# Residual Correlations

```
mxMatrix( type="Diag", nrow=nv, ncol=nv, free=T,  
          values=.1, name="resCorMZ"),
```



# Covariances due to Common Factor -MZ

within twins:

```
mxAlgebra(
  expression=
  facL %% t(facL),
  name="facVar"),
```

across MZ twins:

```
mxAlgebra(
  expression=
  facL %% facCorMZ %% t(facL),
  name="facCovMZ"),
```

		T1				T2			
		m3	m7	m10	m12	m3	m7	m10	m12
T1	m3	facVar				facCovMZ			
	m7								
	m10								
	m12								
T2	m3	facCovMZ				facVar			
	m7								
	m10								
	m12								

# Covariances due to Common Factor -DZ

within twins:

```
mxAlgebra(
  expression=
  facL %% t(facL),
  name="facVar"),
```

across DZ twins:

```
mxAlgebra(
  expression=
  facL %% facCorDZ %% t(facL),
  name="facCovDZ"),
```

		T1				T2			
		m3	m7	m10	m12	m3	m7	m10	m12
T1	m3	facVar				facCovDZ			
	m7								
	m10								
	m12								
T2	m3	facCovDZ				facVar			
	m7								
	m10								
	m12								



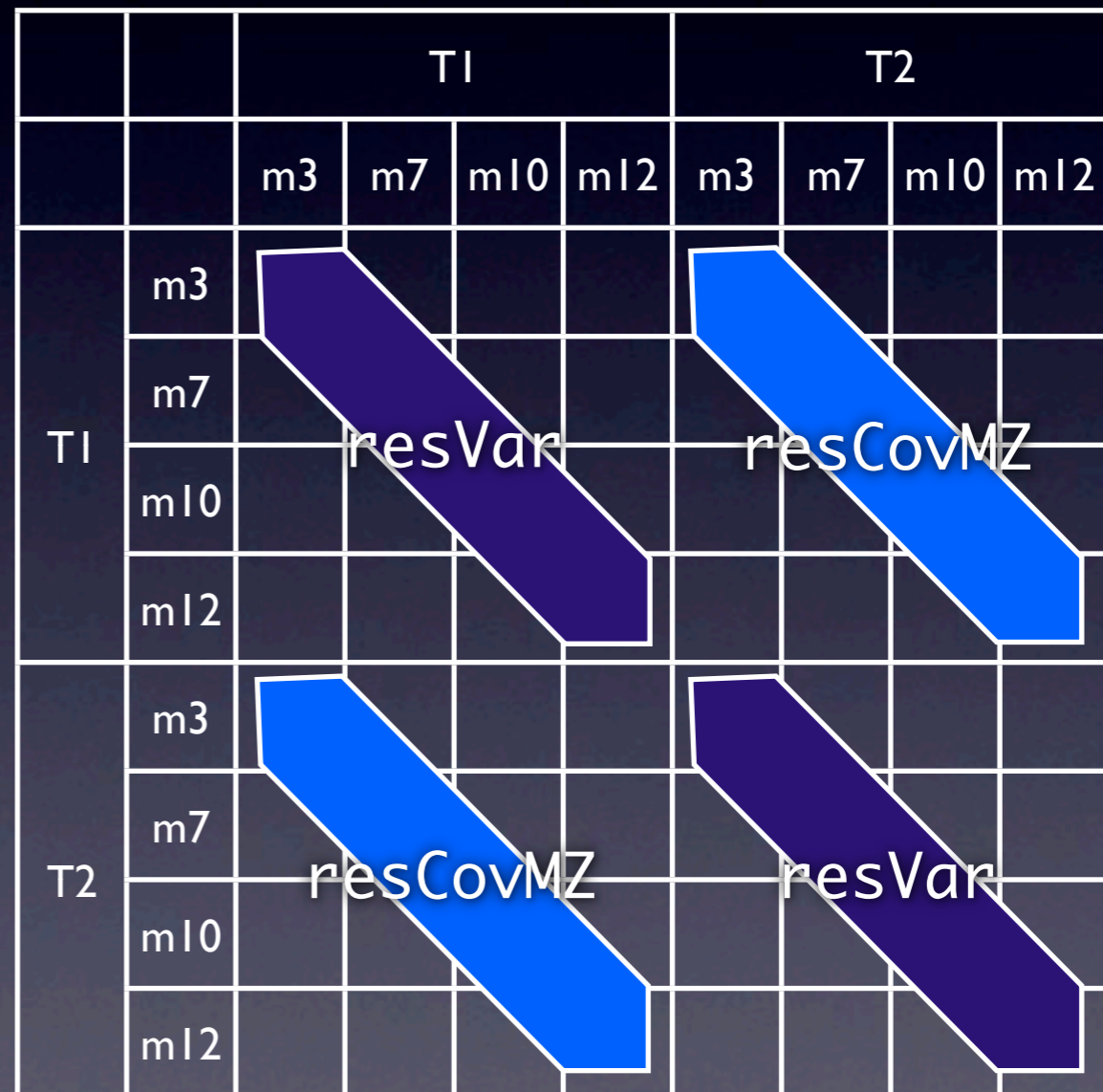
# Residual Variances -MZ

within twins:

```
mxAlgebra(
  expression=
  res %*% t(res),
  name="resVar"),
```

across MZ twins:

```
mxAlgebra(
  expression=
  res %*% resCorMZ %*% t(res),
  name="resCovMZ"),
```



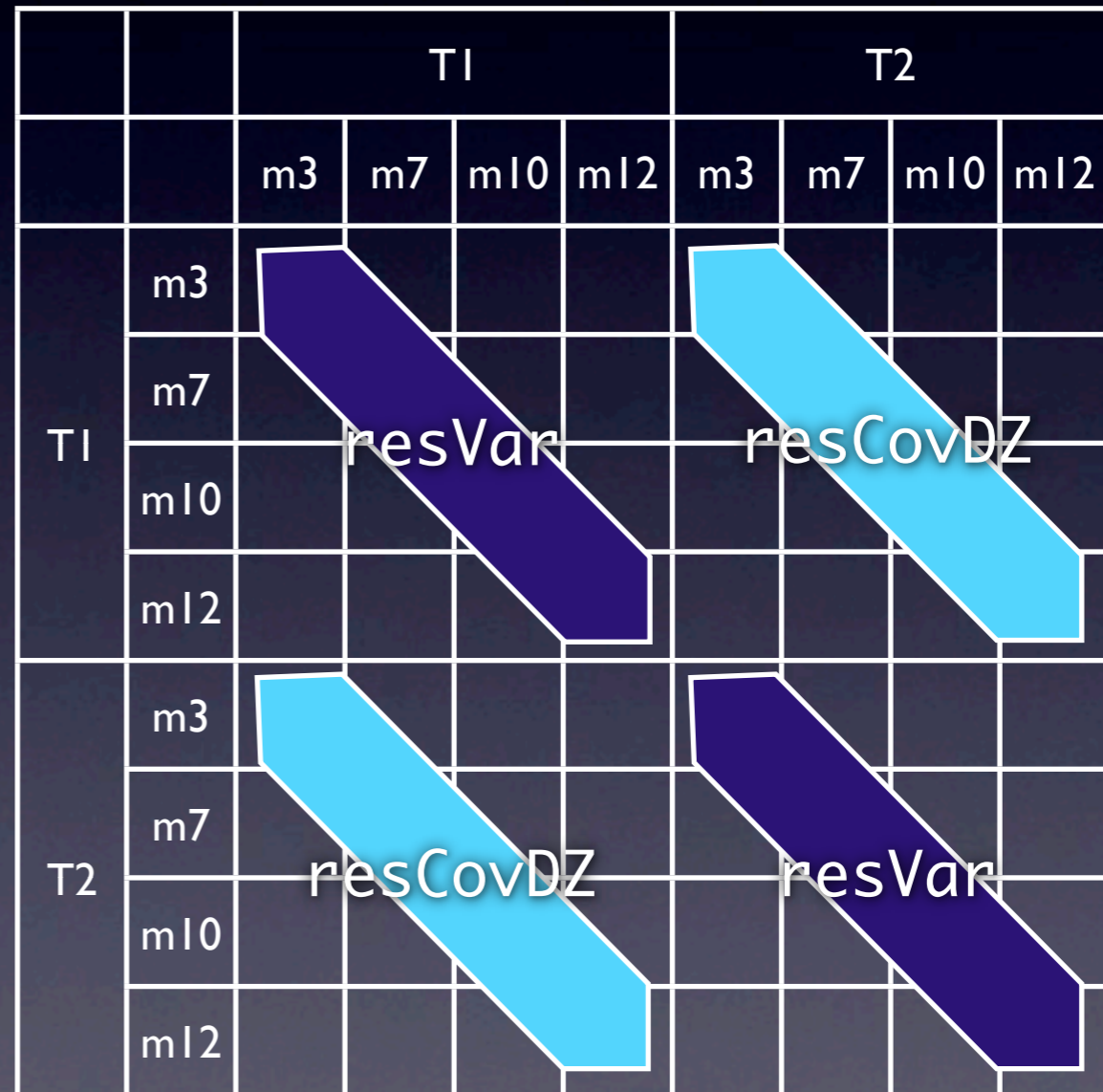
# Residual Variances -DZ

within twins:

```
mxAlgebra(
  expression=
  res %*% t(res),
  name="resVar"),
```

across MZ twins:

```
mxAlgebra(
  expression=
  res %*% resCorMZ %*% t(res),
  name="resCovDZ")
```



# Total (Co)Variances -MZ

```
mxAlgebra(
  expression=
  rbind(
    cbind(facVar + resVar,
          facCovMZ + resCovMZ),
    cbind(facCovMZ + resCovMZ,
          facVar + resVar)),
  name="covMZ"),
```

		T1				T2			
		m3	m7	m10	m12	m3	m7	m10	m12
T1	m3	<div style="background-color: #4b0082; color: white; padding: 10px; text-align: center;">           facVar + resVar         </div>				<div style="background-color: #007bff; color: white; padding: 10px; text-align: center;">           facCovMZ + resCovMZ         </div>			
	m7								
	m10								
	m12								
T2	m3	<div style="background-color: #007bff; color: white; padding: 10px; text-align: center;">           facCovMZ + resCovMZ         </div>				<div style="background-color: #4b0082; color: white; padding: 10px; text-align: center;">           facVar + resVar         </div>			
	m7								
	m10								
	m12								



# Total (Co)Variances -DZ

```
mxAlgebra(
  expression=
  rbind(
    cbind(facVar + resVar,
          facCovDZ + resCovDZ),
    cbind(facCovDZ + resCovDZ,
          facVar + resVar)),
  name="covDZ"),
```

		T1				T2			
		m3	m7	m10	m12	m3	m7	m10	m12
T1	m3	<div style="background-color: #4b0082; color: white; padding: 10px; text-align: center;">           facVar + resVar         </div>				<div style="background-color: #ff9900; color: white; padding: 10px; text-align: center;">           facCovDZ + resCovDZ         </div>			
	m7								
	m10								
	m12								
T2	m3	<div style="background-color: #ff9900; color: white; padding: 10px; text-align: center;">           facCovDZ + resCovDZ         </div>				<div style="background-color: #4b0082; color: white; padding: 10px; text-align: center;">           facVar + resVar         </div>			
	m7								
	m10								
	m12								

# Total (Co)Variances

## -MZ

## -DZ

		T1				T2			
		m3	m7	m10	m12	m3	m7	m10	m12
T1	m3	$\text{facVar} + \text{resVar}$				$\text{facCovMZ} + \text{resCovMZ}$			
	m7								
	m10								
	m12								
T2	m3	$\text{facCovMZ} + \text{resCovMZ}$				$\text{facVar} + \text{resVar}$			
	m7								
	m10								
	m12								

		T1				T2			
		m3	m7	m10	m12	m3	m7	m10	m12
T1	m3	$\text{facVar} + \text{resVar}$				$\text{facCovDZ} + \text{resCovDZ}$			
	m7								
	m10								
	m12								
T2	m3	$\text{facCovDZ} + \text{resCovDZ}$				$\text{facVar} + \text{resVar}$			
	m7								
	m10								
	m12								

# Parameter 'Group'

```
mxModel("All",  
  mxMatrix(..., name="Mean"),  
  .... Beta, facL, res, facCorMZ, facCorDZ,  
  resCorMZ, resCorDZ  
  mxAlgebra(..., name="facVar"),  
  .... facCovMZ, facCovDZ, resVar, resCovMZ,  
  resCovDZ, covMZ, covDZ  
  .... Var, invSD, stFacL, stRes, StVar  
)
```



# Data 'Group'

```
mxModel("MZM",  
  mxData(mzmPData, "raw"),  
  mxMatrix( type="Full", nrow=1, ncol=2, free=F,  
    labels=c"data.SEXt1", "data.SEXt2"), name="sex"),  
  mxAlgebra( expression= cbind(All.Mean, All.Mean) +  
    sex %x% All.Beta, name="mean"),  
  mxFIMLObjective( covariance="All.covMZ",  
    means="mean", dimnames=manifestVars)  
),
```

```
mzmPData <-  
  “mzmP.dat”
```

```
mo3t1 fa3t1 mo7t1 fa7t1 mo10t1 fa10t1 mo12t1 fa12t1  
mo3t2 fa3t2 mo7t2 fa7t2 mo10t2 fa10t2 mo12t2 fa12t2  
SEXt1 SEXt2
```

```
284 1 . 2 . 0 . 0 0 3 . 2 . 1 . 0 0 1 1
```

```
285 3 3 2 1 4 3 3 2 4 6 2 2 4 3 3 3 1 1
```

```
287 2 . . . 3 1 1 0 2 . . . 3 1 1 0 1 1
```

```
289 7 8 . . 8 9 3 4 7 9 . . 6 5 2 2 1 1
```

# Means & Regressions on Sex

mean=

`cbind(Mean, Mean)`

+ `sex %x% All.Beta`

`sex= [data.SEXt1, data.SEXt2]`

		T1				T2			
		m3	m7	m10	m12	m3	m7	m10	m12
x		Mean				Mean			
		m3	m7	m10	m12	m3	m7	m10	m12
		Beta				Beta			

1x8 [meanm3+ beta1\*SEXt1, meanm7+ beta2\*SEXt1, meanm10+ beta3\*SEXt1, meanm12+ beta4\*SEXt1, meanm3+ beta1\*SEXt2, meanm7+ beta2\*SEXt2, meanm10+ beta3\*SEXt2, meanm12+ beta4\*SEXt2]



# Running OpenMx

```
factorModel <- mxModel("factor", ...)
```

```
factorFit <- mxRun(factorModel)
```

```
factorSumm <- summary(factorFit)
```

```
factorSumm
```

```
factorModel$All$facL
```

```
factorFit$All$facL
```

# Exercise

- Run Att4P.R
- Change to include father's ratings

m

