Model Specification

STRUCTURAL EQUATION MODELING WITH LAVAAN IN R

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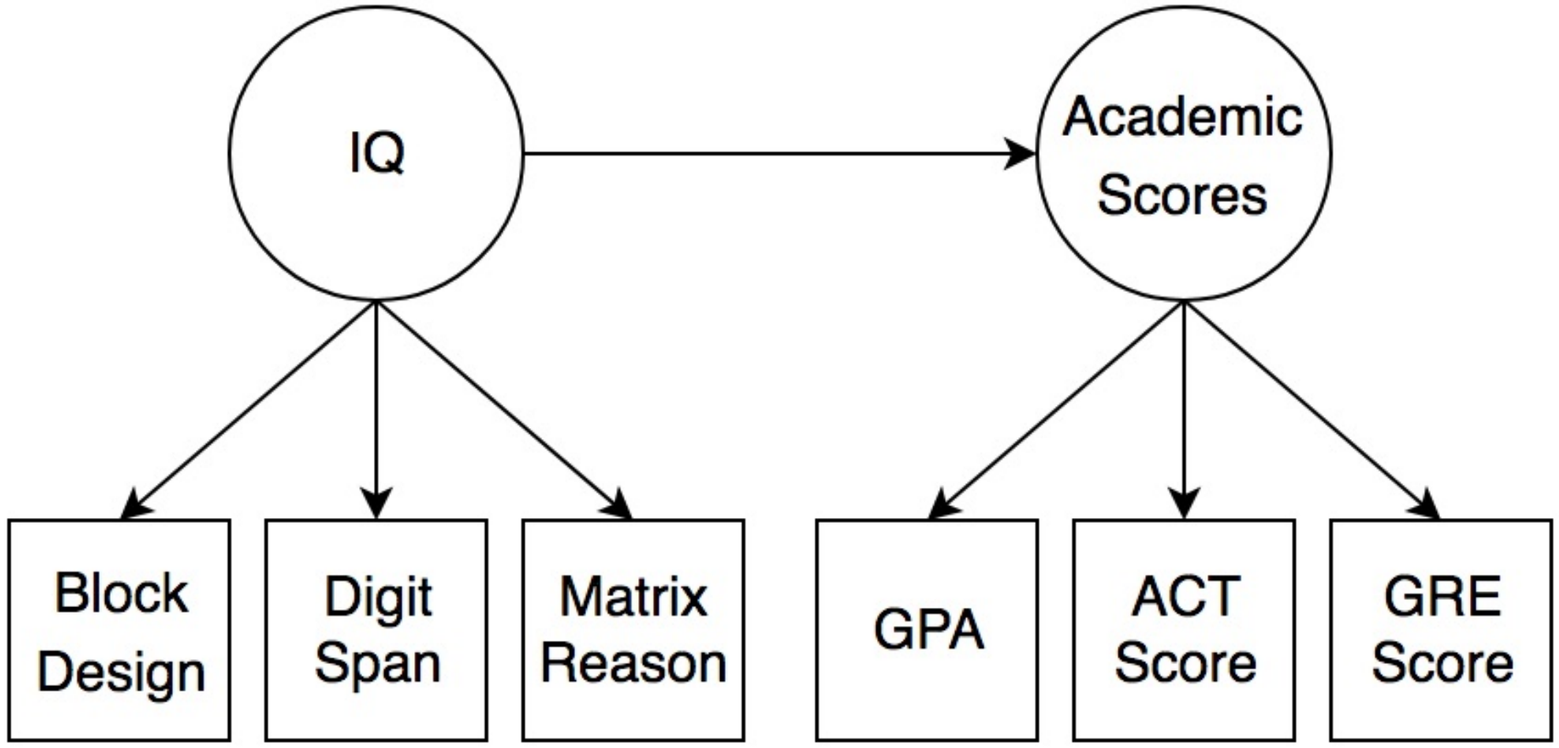
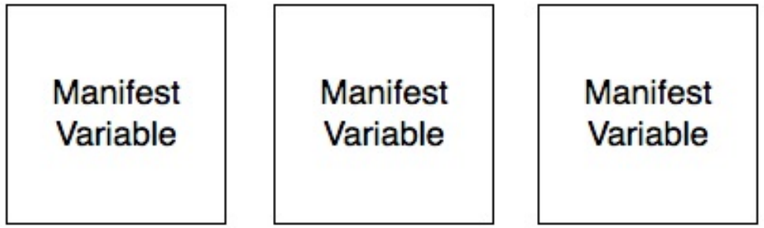
SEM Goals

- Explore the relationship between variables
- Confirm the structure of a developed model

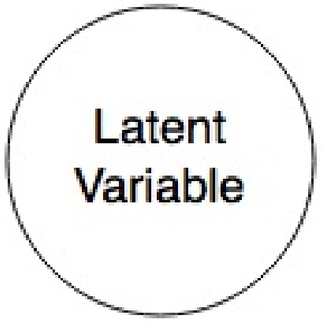


Variables

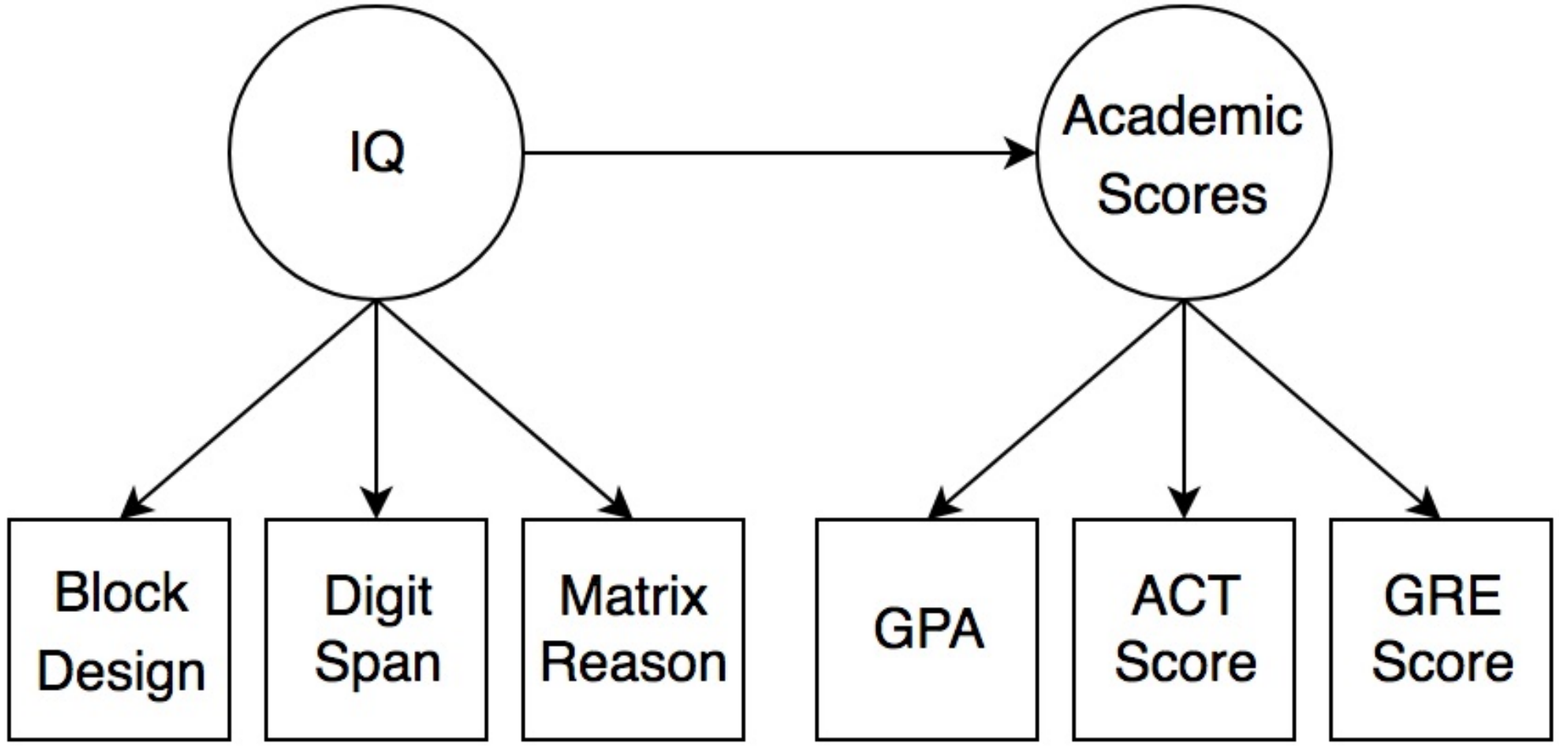
- Manifest variables:
  - Real numbers in your dataset
  - Represented by squares



- Latent variables:
  - Phenomenon measured by manifest variables
  - Represented by circles



Example Model



Set Up Your Model

```
library(lavaan)
data(HolzingerSwineford1939)
```

```
head(HolzingerSwineford1939[7:15])
```

```
        x1   x2    x3       x4   x5        x6       x7   x8       x9
1 3.333333 7.75 0.375 2.333333 5.75 1.2857143 3.391304 5.75 6.361111
2 5.333333 5.25 2.125 1.666667 3.00 1.2857143 3.782609 6.25 7.916667
3 4.500000 5.25 1.875 1.000000 1.75 0.4285714 3.260870 3.90 4.416667
4 5.333333 7.75 3.000 2.666667 4.50 2.4285714 3.000000 5.30 4.861111
5 4.833333 4.75 0.875 2.666667 4.00 2.5714286 3.695652 6.30 5.916667
6 5.333333 5.00 2.250 1.000000 3.00 0.8571429 4.347826 6.65 7.500000
```

Set Up Your Model (2)

```
#an example
model <- 'latent_variable =~ manifest_variable1 + ...'
```

```
#our model
visual.model <- 'visual =~ x1 + x2 + x3 + x7 + x8 + x9'
```

Let's practice!

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Model Analysis

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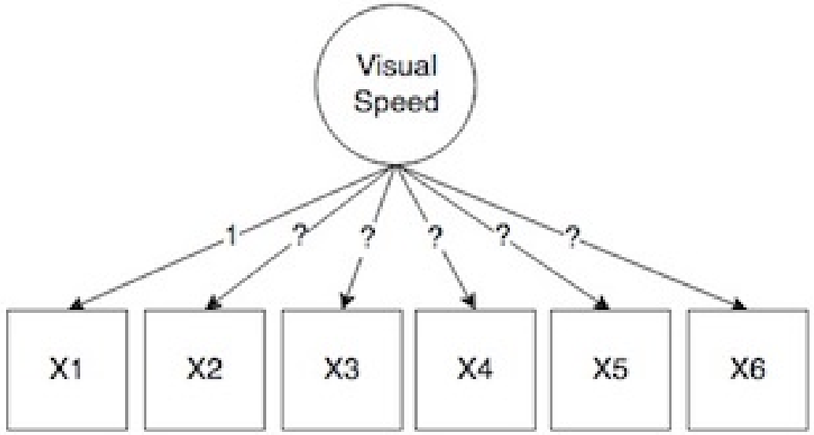
Model Terms

- Degrees of Freedom (df)
  - Determined by the number of manifest variables and estimated values
  - df = Possible Values - Estimated Values
  - Possible Values = Manifest Variables * (Manifest Variables + 1) / 2
- Identification
  - Include at least three manifest variables
  - Create models with df > 0
  - Use scaling and constraints to control df

Analyze the Model

```
#model specification
visual.model <- 'visual =~ x1 + x2 + x3 + x7 + x8 + x9'
```

```
#model analysis
visual.fit <- cfa(model = visual.model,
                  data = HolzingerSwineford1939)
```



Summarize the Results Overall

```
summary(visual.fit)
```

```
lavaan (0.5-23.1097) converged normally after  27 iterations

  Number of observations                           301

  Estimator                                         ML
  Minimum Function Test Statistic               106.553
  Degrees of freedom                                 9
  P-value (Chi-square)                           0.000

Parameter Estimates:
```

Summarize the Results Loadings

```
Latent Variables:
                   Estimate  Std.Err  z-value  P(>|z|)
  visual =~
    x1                1.000
    x2                0.586    0.139    4.215    0.000
    x3                0.882    0.149    5.923    0.000
    x7                0.728    0.137    5.320    0.000
    x8                0.944    0.143    6.599    0.000
    x9                1.205    0.170    7.095    0.000
```

Summarize the Results Variances

```
Variances:
                   Estimate  Std.Err  z-value  P(>|z|)
   .x1                0.973    0.093   10.405    0.000
   .x2                1.249    0.106   11.789    0.000
   .x3                0.975    0.090   10.842    0.000
   .x7                0.979    0.087   11.311    0.000
   .x8                0.678    0.069    9.841    0.000
   .x9                0.455    0.069    6.580    0.000
    visual            0.386    0.092    4.201    0.000
```

Let's practice!

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Model Assessment

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Standardized Loadings

```
summary(visual.fit, standardized = TRUE)
```

```
Latent Variables:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
  visual =~
    x1                1.000                               0.621    0.533
    x2                0.586    0.139    4.215    0.000    0.364    0.310
    x3                0.882    0.149    5.923    0.000    0.548    0.485
    x7                0.728    0.137    5.320    0.000    0.452    0.416
    x8                0.944    0.143    6.599    0.000    0.586    0.580
    x9                1.205    0.170    7.095    0.000    0.748    0.742
```

Fit Indices

- Model Fit - how well the data fit the specified model
  - Goodness of fit indices like the Comparative Fit Index (CFI) or the Tucker Lewis Index (TLI)
  - Badness of fit indices like Root Mean Square Error of Approximation (RMSEA) or Standardized Root Mean Square Residual (SRMR)
- **Measuring Model Fit**

Fit Indices

```
summary(visual.fit, standardized = TRUE,
        fit.measures = TRUE)
```

```
User model versus baseline model:
  Comparative Fit Index (CFI)                    0.701
  Tucker-Lewis Index (TLI)                       0.502

                      - - -
Root Mean Square Error of Approximation:
  RMSEA                                          0.190

                      - - -
Standardized Root Mean Square Residual:
  SRMR                                           0.111
```

Let's practice!

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