Latent Growth Curve Modelling

A **very** brief introduction

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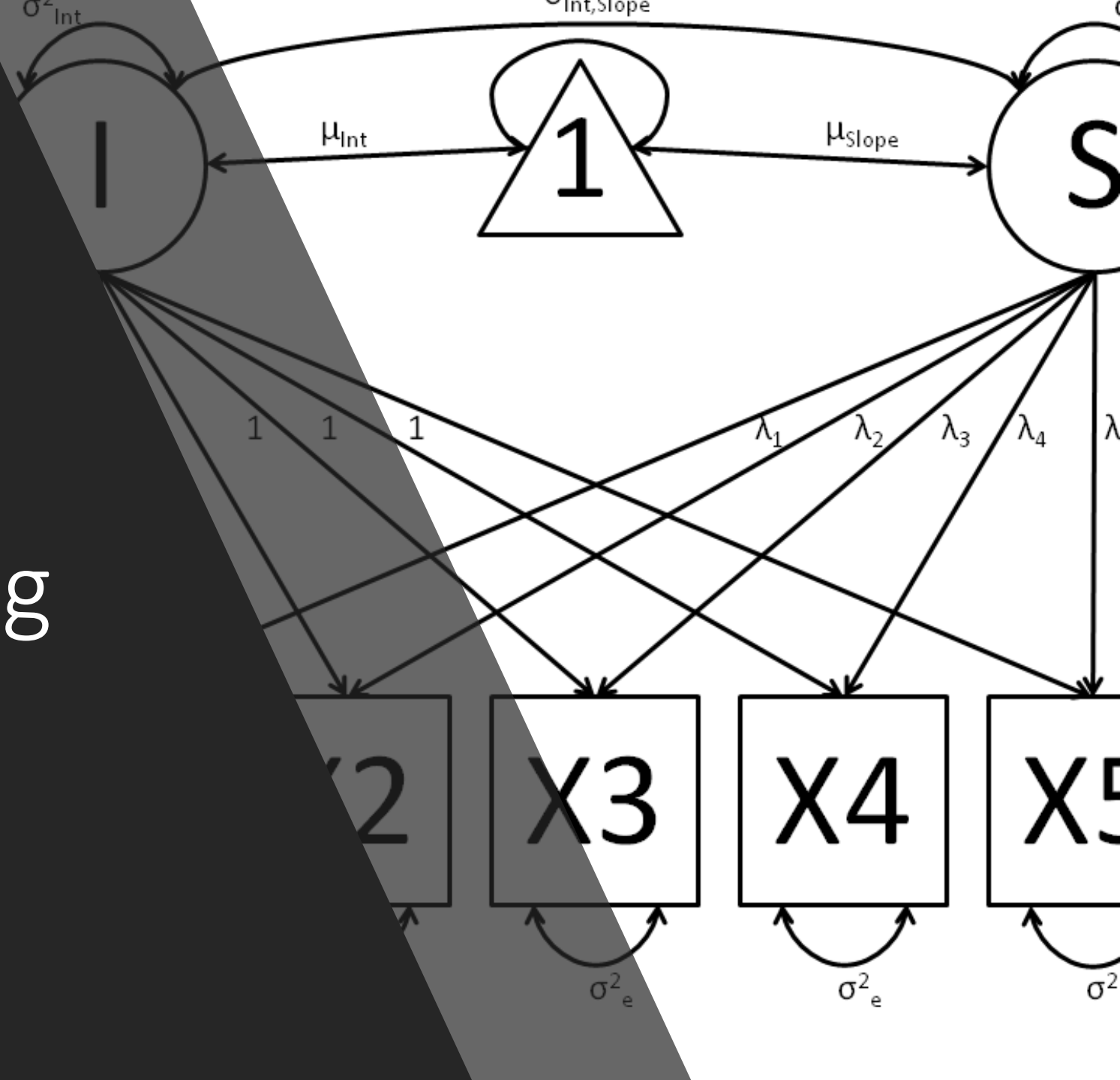


Summary

- What are latent growth models?
- Example using R and lavaan (R Package)

Time permitting:

- Extensions to simple latent growth models.

Latent Growth Curve Models

Latent Growth Curve Models (LGCM) offer a flexible solution to the problem of analysing change over time.

We can use LGCM to examine questions such as…

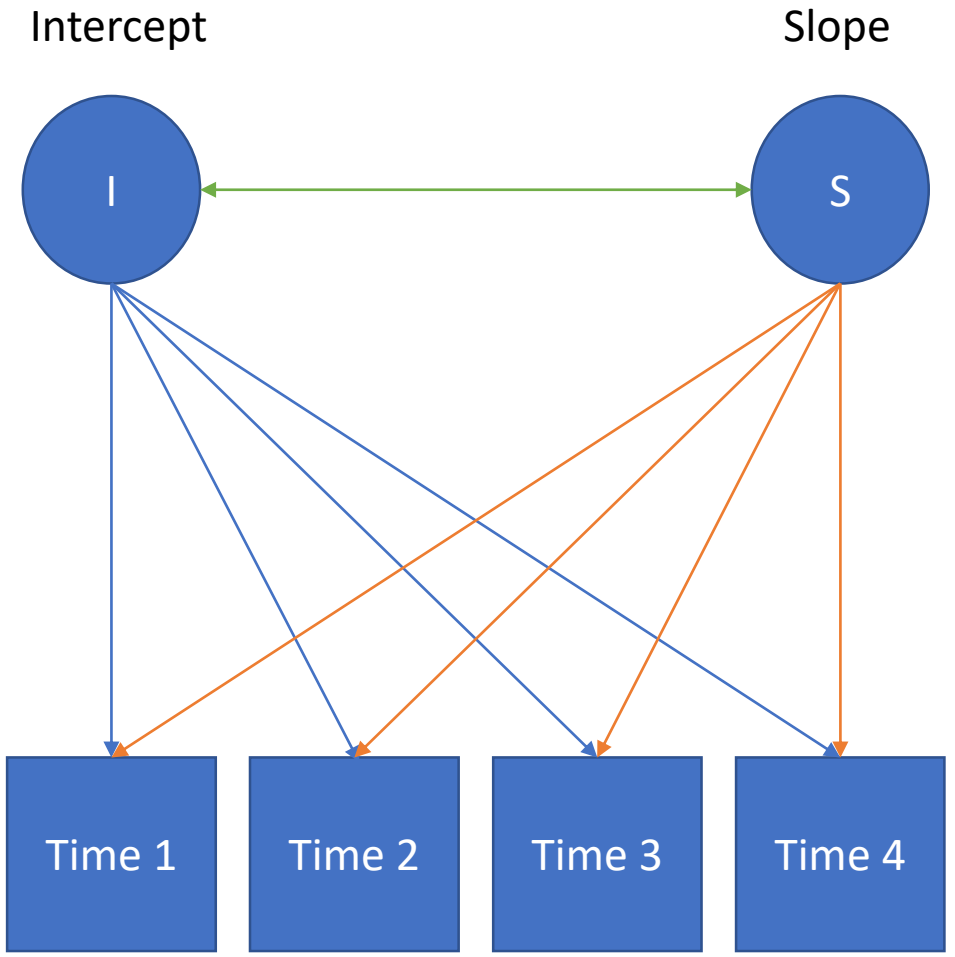
- What is the shape of change over time?
- Does change vary between subjects?
- Which variables predict the rate of change?
- Does change in one variable predict change in another?

LGCM vs Multilevel Models

- LCGMs differ from longitudinal multilevel modelling approaches by analysing the data at the subject level (i.e. as in repeated measures ANOVA).
- These repeated observations are treated as measures of indicators of latent variables representing the level of and change in the construct being assessed over time.

- In MLMs individual differences in growth over time are captured by random coefficients. However, within these approaches, statistical modelling has been largely limited to a single response variable. As such, they do not fully accommodate the complexity and analytical needs of current developmental theories

In a LGCM the observations of our construct(s) of interest over time are modelled as indicators (i.e. measures) of latent variables representing the true **intercept** and **slope** (and if a non-linear change is hypothesised then the degree of curvilinearity) of a 'growth curve' that describes the level of and change in the construct over time…

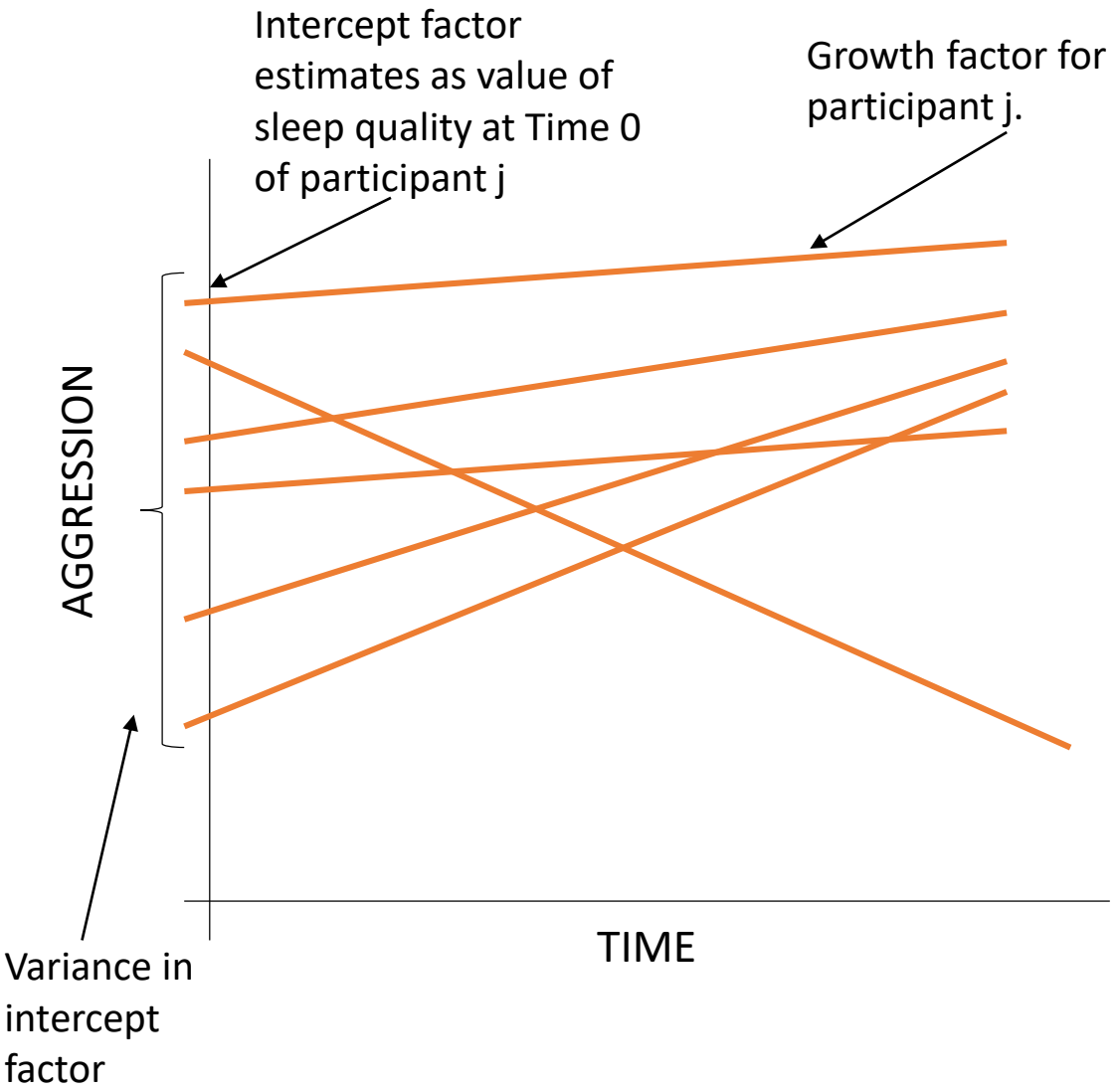


Observed measures of aggression in adolescents at Time 1 – Time 4. (Note: This measures do not have to be observed, they could also be latent variables

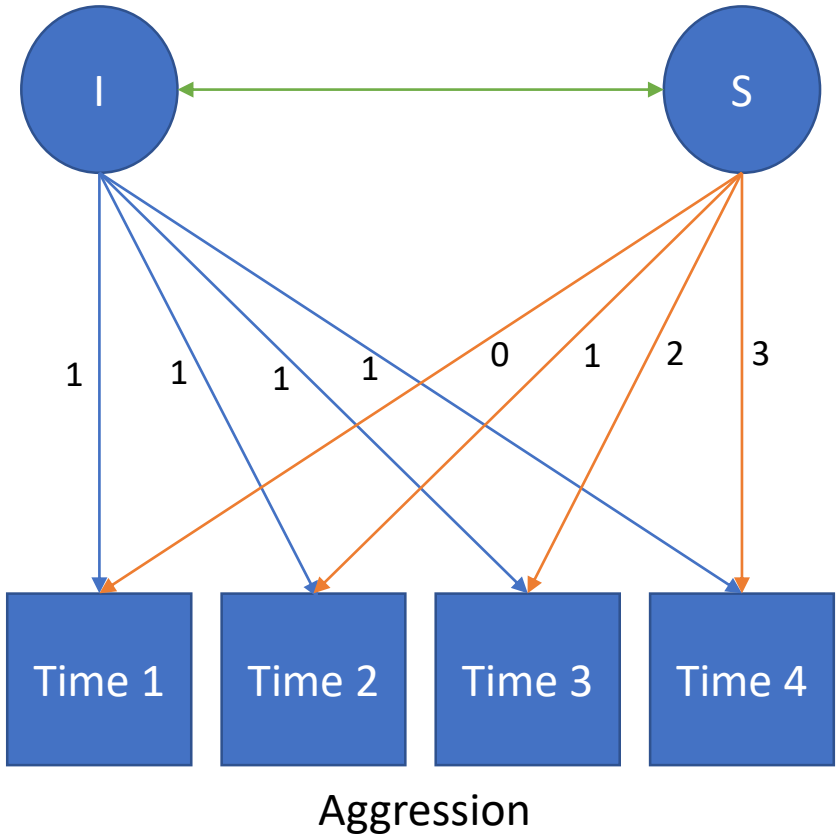
When we fit an LGCM we are typically interested in estimating:

1. The intercept factor mean (i.e. the 'starting' level)
2. The intercept factor variance (the extent to which the starting level differs amongst subjects)
3. The slope factor mean (i.e. the average rate of change over time)
4. The slope factor variance (the extent to which the rate of change varies between subjects)

We can also estimate the covariance between the intercept and slope, this enables us to assess whether the level a subject starts at promotes or inhibits their progress over time.



Basic Growth Model Example – R (lavaan)




```
# linear growth model with 4 timepoints
# intercept and slope
model <-
'i =~ 1*t1 + 1*t2 + 1*t3 + 1*t4
 s =~ 0*t1 + 1*t2 + 2*t3 + 3*t4'
fit <- growth (model, data = df)
summary (fit)
```

Note:
R Lavaan code
=~ latent variable (BY in Mplus)
~ regression (ON in Mplus)
~~ covariance (WITH in Mplus)

lavaan (0.6-1.1143) converged normally after 29 iterations

Number of observations	400
Estimator	ML
Model Fit Test Statistic	8.069
Degrees of freedom	5
P-value (Chi-square)	0.152

Model fit (you can also request additional fit indices)

Parameter Estimates:

Information	Expected
Standard Errors	Standard

Latent Variables:

	Estimate	Std.Err	z-value	P(>|z|)
i =~				
t1	1.000			
t2	1.000			
t3	1.000			
t4	1.000			
s =~				
t1	0.000			
t2	1.000			
t3	2.000			
t4	3.000			

Output re-specifies model here

Covariances:

	Estimate	Std.Err	z-value	P(>|z|)
i ~~				
s	0.618	0.071	8.686	0.000

Covariance between intercept and slope

Intercepts:

	Estimate	Std.Err	z-value	P(>|z|)
.t1	0.000			
.t2	0.000			
.t3	0.000			
.t4	0.000			
i	0.615	0.077	8.007	0.000
s	1.006	0.042	24.076	0.000

Average intercept (starting point) and average growth over time

Variances:

	Estimate	Std.Err	z-value	P(>|z|)
.t1	0.595	0.086	6.944	0.000
.t2	0.676	0.061	11.061	0.000
.t3	0.635	0.072	8.761	0.000
.t4	0.508	0.124	4.090	0.000
i	1.932	0.173	11.194	0.000
s	0.587	0.052	11.336	0.000

How much does the intercept and slope vary across our sample? Is this variation significantly different from zero?

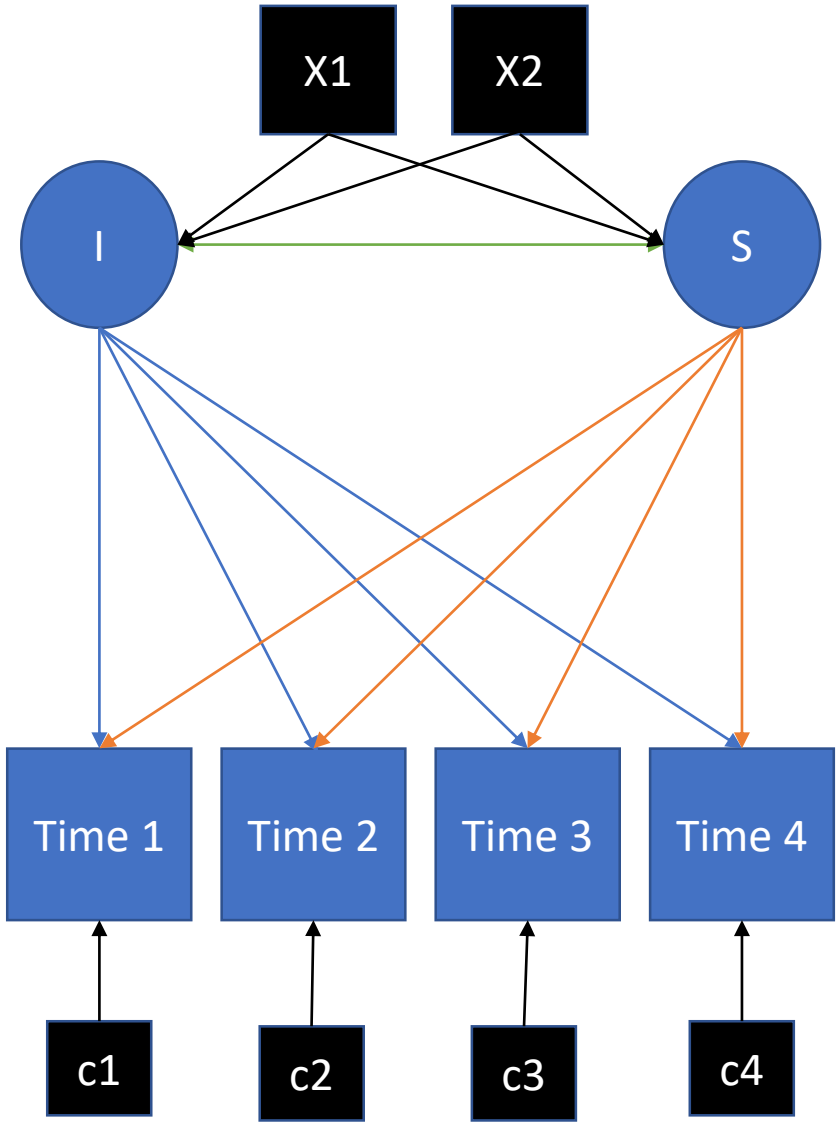
Note: Example from lavaan growth model example data

Extensions to the basic growth model

There are many extensions available to this basic growth model, including:

- The addition of covariates
- The addition of parallel growth models
- Variation in coding of time
- Measuring constructs using factors (latent variables)
- Addition of multiple slope factors (useful for examining interventions)

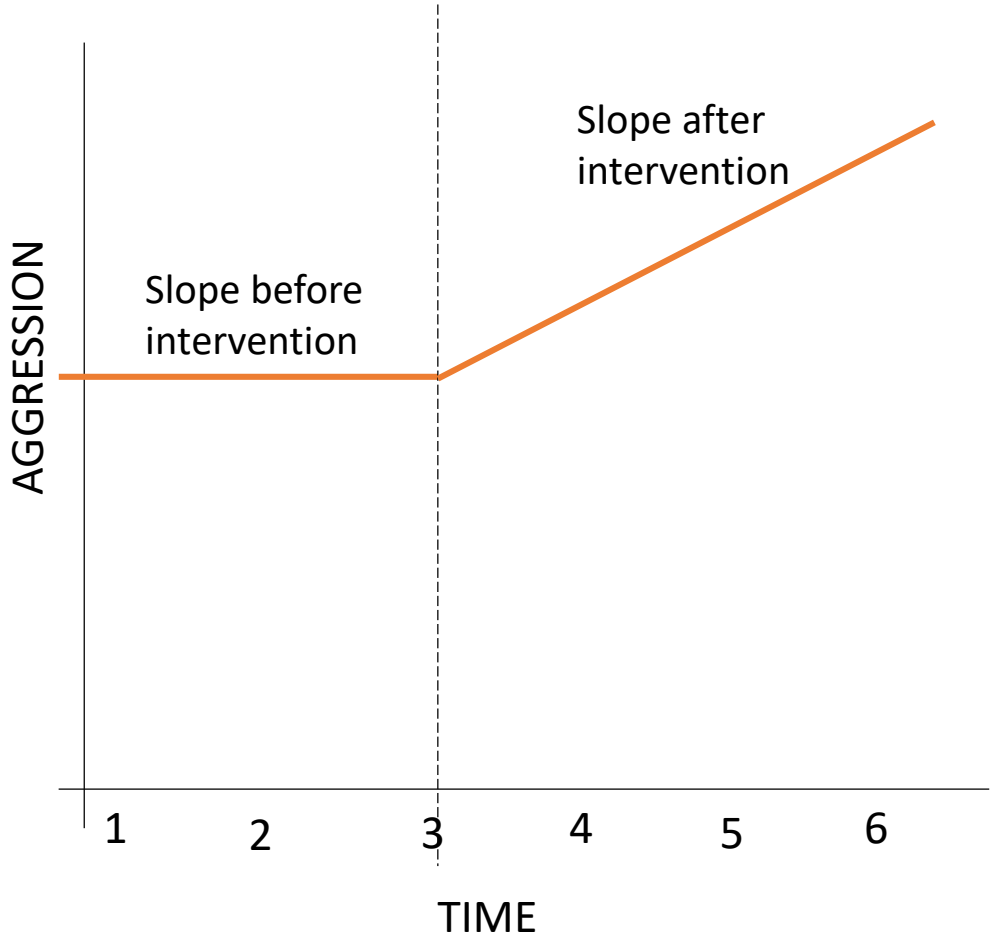
Adding covariates and predictors - Example




```
# a linear growth model with a time-varying
covariate and predictors

model <- '
  # intercept and slope with fixed
coefficients
    i =~ 1*t1 + 1*t2 + 1*t3 + 1*t4
    s =~ 0*t1 + 1*t2 + 2*t3 + 3*t4
  # regressions
    i ~ x1 + x2
    s ~ x1 + x2
  # time-varying covariates
    t1 ~ c1
    t2 ~ c2
    t3 ~ c3
    t4 ~ c4
'
fit <- growth(model, data = df)
summary(fit)
```

Adding piecewise elements to growth curve - Example

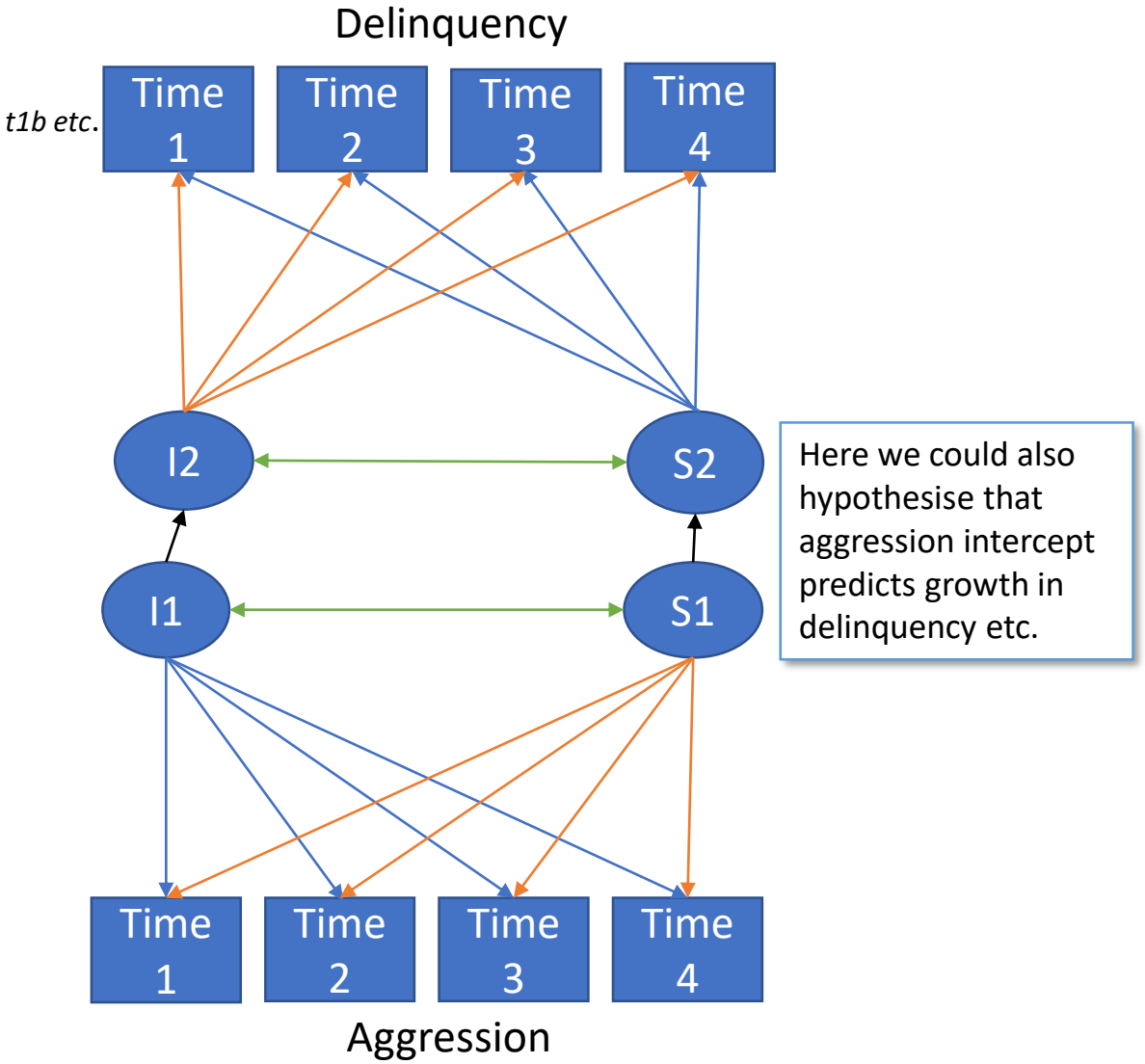



```
# a linear growth model with new piece element at Time 3

model <- '
  # intercept and slopes with fixed coefficients
    i1=~ 1*t1 + 1*t2 + 1*t3 + 1*t4 + 1*t5 + 1*t6
    s1=~ 0*t1 + 1*t2 + 2*t3 + 2*t4 + 2*t5 + 2*t6
    s2=~ 0*t1 + 0*t2 + 0*t3 + 1*t4 + 2*t5 + 3*t6

'
fit <- growth(model, data = df)
summary(fit)
```

Extension: Parallel Growth Curves



Here we could also hypothesise that aggression intercept predicts growth in delinquency etc.

```
# multiple linear growth model with 4
timepoints
# intercept and slope for aggression and
delinquency
model <-
'i1 =~ 1*t1 + 1*t2 + 1*t3 + 1*t4
 s1 =~ 0*t1 + 1*t2 + 2*t3 + 3*t4

 i1 =~ 1*tb1 + 1*tb2 + 1*tb3 + 1*tb4
 s1 =~ 0*tb1 + 1*tb2 + 2*tb3 + 3*tb4
# regress aggression intercept onto
delinquency intercept
 i2 ~ i1
# regress aggression intercept onto
delinquency intercept

 s2 ~ s1'

fit <- growth (model, data = df)
summary (fit)
```

Resources

Lavaan R Package:

http://lavaan.ugent.be/tutorial/index.html

http://blogs.baylor.edu/rlatentvariable/sample-page/r-syntax/

Papers/Books:

Curran, P. J., Bauer, D. J., & Willoughby, M. T. (2004). Testing main effects and interactions in latent curve analysis. *Psychological Methods*, *9*(2), 220 – 237

Curran, P. J., Obeidat, K., & Losardo, D. (2010). Twelve frequently asked questions about growth curve modeling. *Journal of Cognition and Development*, *11*(2), 121-136.

Duncan, T. E., & Duncan, S. C. (2009). The ABC's of LGM: an introductory guide to latent variable growth curve modeling. *Social and personality psychology compass*, *3*(6), 979-991.

Jung, T., & Wickrama, K. A. S. (2008). An introduction to latent class growth analysis and growth mixture modeling. *Social and personality psychology compass*, *2*(1), 302-317.

Little, T. D. (2013). *Longitudinal structural equation modeling*. Guilford: Guilford Press.