Further Readings On Introductory Growth Modeling

Bijleveld, C. C. J. H., & van der Kamp, T. (1998). Longitudinal data analysis: Designs, models, and methods. Newbury Park: Sage.

Bollen, K.A. & Curran, P.J. (2006). Latent curve models. A structural equation perspective. New York: Wiley.

Muthén, B. & Khoo, S.T. (1998). Longitudinal studies of achievement growth using latent variable modeling. Learning and Individual Differences, Special issue: latent growth curve analysis, 10, 73-101. (#80)

Muthén, B. & Muthén, L. (2000). The development of heavy drinking and alcohol-related problems from ages 18 to 37 in a U.S. national sample. Journal of Studies on Alcohol, 61, 290-300. (#83)

Raudenbush, S.W. & Bryk, A.S. (2002). Hierarchical linear models: Applications and data analysis methods. Second edition. Newbury Park, CA: Sage Publications.

Singer, J.D. & Willett, J.B. (2003). Applied longitudinal data analysis. Modeling change and event occurrence. New York, NY: Oxford University Press.

Snijders, T. & Bosker, R. (1999). Multilevel analysis. An introduction to basic and advanced multilevel modeling. Thousand Oakes, CA: Sage Publications.

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Further Practical Issues

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Five Ways To Model Non-Linear Growth

- Estimated time scores
- Quadratic (cubic) growth model
- Fixed non-linear time scores
- Piece-wise growth modeling
- Time-varying covariates

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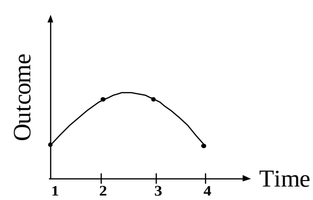
Specifying Time Scores For Quadratic Growth Models

Quadratic growth model

$$y_{ti} = \eta_{0i} + \eta_{1i} x_t + \eta_{2i} x_t^2 + \varepsilon_{ti}$$

- Need three latent variables to describe a quadratic growth model: Intercept, linear slope, quadratic slope



- Linear slope time scores: 0 1 2 3
  0 .1 .2 .3
- Quadratic slope time scores: 0 1 4 9
  0 .01 .04 .09

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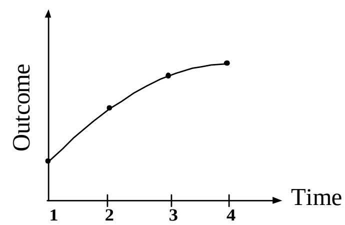
Specifying Time Scores For Non-Linear Growth Models With Fixed Time Scores

Non-Linear Growth Models with Fixed Time scores

- Need two latent variables to describe a non-linear growth model: Intercept and slope

Growth model with a logarithmic growth curve--ln(t)



Time scores: 0 0.69 1.10 1.39

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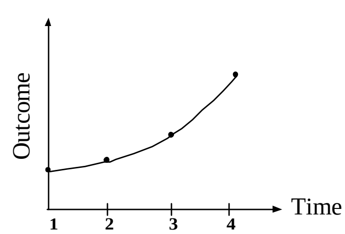
Specifying Time Scores For Non-Linear Growth Models With Fixed Time Scores (Continued)

Growth model with an exponential growth curve–
exp(t-1) - 1



Time scores: 0 1.72 6.39 19.09

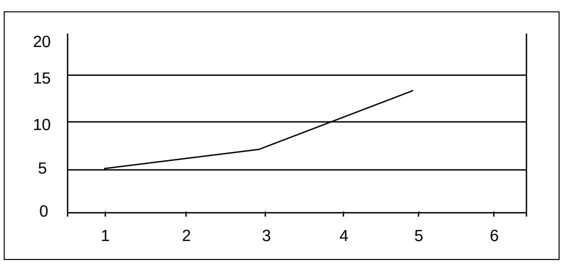
100

Piecewise Growth Modeling

101

Piecewise Growth Modeling

- Can be used to represent different phases of development
- Can be used to capture non-linear growth
- Each piece has its own growth factor(s)
- Each piece can have its own coefficients for covariates



One intercept growth factor, two slope growth factors

0	1	2	2	2	2	Time scores piece 1
0	0	0	1	2	3	Time scores piece 2

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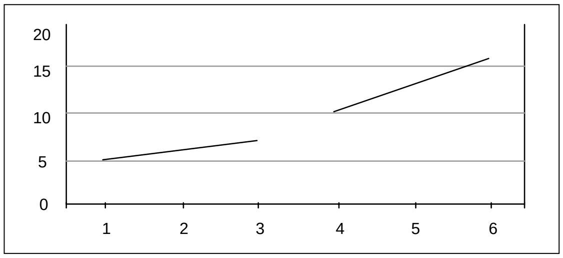
Piecewise Growth Modeling (Continued)



Two intercept growth factors, two slope growth factors

0	1	2				Time scores piece 1
			0	1	2	Time scores piece 2

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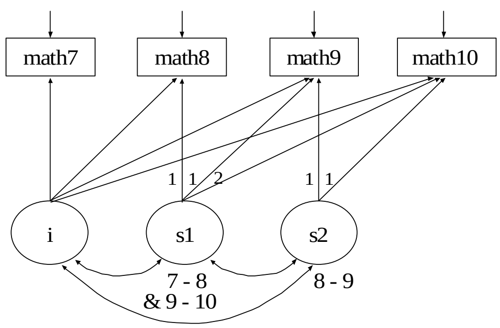

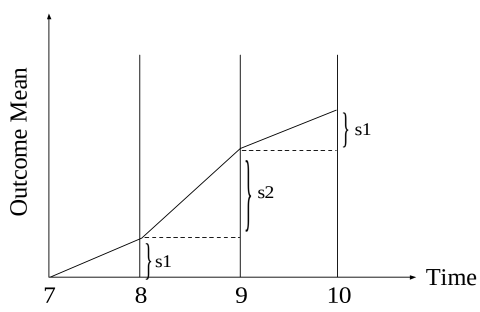

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Input For LSAY Piecewise Growth Model With Covariates

```
MODEL:     i s1 | math7@0 math8@1 math9@1 math10@2;
           i s2 | math7@0 math8@0 math9@1 math10@1;
           i s1 s2 ON mothed homeres;
```

```
Alternative language:
```

```
MODEL:     i BY math7-math10@1;
           s1 BY math7@0 math8@1 math9@1 math10@2;
           s2 BY math7@0 math8@0 math9@1 math10@1;
           [math7-math10@0];
           [i s1 s2];
           i s1 s2 ON mothed homeres;
```

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Output Excerpts LSAY Piecewise Growth Model With Covariates

n = 935

Tests of Model Fit

```
CHI-SQUARE TEST OF MODEL FIT

          Value                         11.721
          Degrees of Freedom                 3
          P-Value                        .0083

RMSEA (ROOT MEAN SQUARE ERROR OF APPROXIMATION)

          Estimate                        .056
          90 Percent C.I.                 .025   .091
          Probability RMSEA <= .05        .331
```

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Output Excerpts LSAY Piecewise Growth Model With Covariates (Continued)

Selected Estimates

	Estimates	S.E.	Est./S.E.	Std	StdYX
I ON					
MOTHED	2.127	.284	7.488	.266	.256
HOMERES	1.389	.185	7.524	.174	.257
S1 ON					
MOTHED	-.126	.147	-.858	-.113	-.109
HOMERES	.091	.096	.950	.081	.120
S2 ON					
MOTHED	**.436**	**.191**	**2.285**	**.185**	**.178**
HOMERES	**.289**	**.124**	**2.329**	**.123**	**.181**

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Growth Model With Individually-Varying Times Of Observation And Random Slopes For Time-Varying Covariates

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Growth Modeling In Multilevel Terms

Time point t, individual i (two-level modeling, no clustering):

y_{ti} : repeated measures of the outcome, e.g. math achievement
a_{1ti} : time-related variable; e.g. grade 7-10
a_{2ti} : time-varying covariate, e.g. math course taking
x_i : time-invariant covariate, e.g. grade 7 expectations

Two-level analysis with individually-varying times of observation and random slopes for time-varying covariates:

$$Level\ 1:\ y_{ti} = \pi_{0i} + \pi_{1i}\, a_{1ti} + \pi_{2ti}\, a_{2ti} + e_{ti}, \tag{55}$$

$$Level\ 2: \begin{cases} \pi_{0i} = ß_{00} + ß_{01}\, x_{\mathrm{i}} + r_{0\mathrm{i}}, \\ \pi_{1i} = ß_{10} + ß_{11}\, x_i + r_{1i}, \\ \pi_{2i} = ß_{20} + ß_{21}\, x_i + r_{2i}. \end{cases} \tag{56}$$

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Growth Modeling In Multilevel Terms (Continued)

Time scores a_{1ti} read in as data (not loading parameters).

- π_{2ti} possible with time-varying random slope variances
- Flexible correlation structure for $V(e) = \Theta$ (T x T)
- Regressions among random coefficients possible, e.g.

$$\pi_{1i} = ß_{10} + \gamma_1\, \pi_{0i} + ß_{11}\, x_i + r_{1i}, \tag{57}$$
$$\pi_{2i} = ß_{20} + \gamma_2\, \pi_{0i} + ß_{21}\, x_i + r_{2i}. \tag{58}$$

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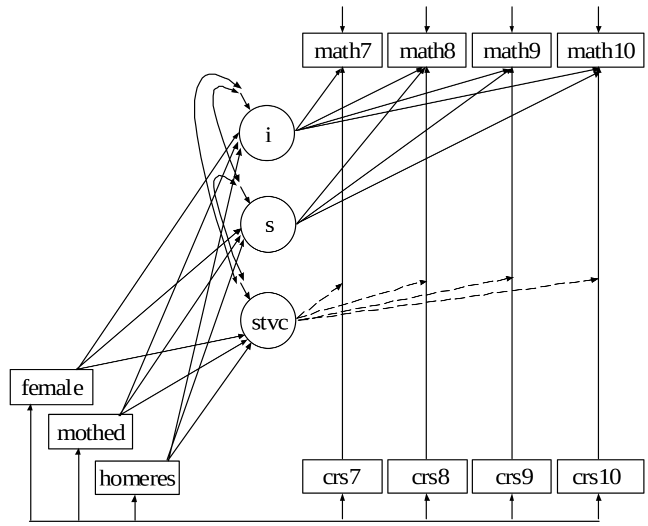

Input For Growth Model With Individually Varying Times Of Observation

```
TITLE:     Growth model with individually varying times of
           observation and random slopes
DATA:      FILE IS lsaynew.dat;
           FORMAT IS 3F8.0 F8.4 8F8.2 3F8.0;
VARIABLE:  NAMES ARE math7 math8 math9 math10 crs7 crs8 crs9
           crs10 female mothed homeres a7-a10;

           ! crs7-crs10 = highest math course taken during each
           ! grade (0=no course, 1=low, basic, 2=average, 3=high.
           ! 4=pre-algebra, 5=algebra I, 6=geometry,
           ! 7=algebra II, 8=pre-calc, 9=calculus)

           MISSING ARE ALL (9999);
           CENTER = GRANDMEAN (crs7-crs10 mothed homeres);
           TSCORES = a7-a10;
```

Input For Growth Model With Individually Varying Times Of Observation (Continued)

```
DEFINE:     math7 = math7/10;
            math8 = math8/10;
            math9 = math9/10;
            math10 = math10/10;
ANALYSIS:   TYPE = RANDOM MISSING;
            ESTIMATOR = ML;
            MCONVERGENCE = .001;
MODEL:      i s | math7-math10 AT a7-a10;
            stvc | math7 ON crs7;
            stvc | math8 ON crs8;
            stvc | math9 ON crs9;
            stvc | math10 ON crs10;
            i ON female mothed homeres;
            s ON female mothed homeres;
            stvc ON female mothed homeres;
            i WITH s;
            stvc WITH i;
            stvc WITH s;
OUTPUT:     TECH8;
```

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Output Excerpts For Growth Model With Individually Varying Times Of Observation And Random Slopes For Time-Varying Covariates

```
n = 2271
```

Tests of Model Fit

```
Loglikelihood

          H0 Value                     -8199.311

Information Criteria

          Number of Free Parameters           22
          Akaike (AIC)                  16442.623
          Bayesian (BIC)                16568.638
          Sample-Size Adjusted BIC      16498.740
             (n* = (n + 2) / 24)
```

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Output Excerpts For Growth Model With Individually Varying Times Of Observation And Random Slopes For Time-Varying Covariates (Continued)

Model Results

	Estimates	S.E.	Est./S.E.
I ON			
FEMALE	0.187	0.036	5.247
MOTHED	0.187	0.018	10.231
HOMERES	0.159	0.011	14.194
S ON			
FEMALE	-0.025	0.012	-2.017
MOTHED	0.015	0.006	2.429
HOMERES	0.019	0.004	4.835
STVC ON			
FEMALE	-0.008	0.013	-0.590
MOTHED	0.003	0.007	0.429
HOMERES	0.009	0.004	2.167
I WITH			
S	0.038	0.006	6.445
STVC WITH			
I	0.011	0.005	2.087
S	0.004	0.002	2.033

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Output Excerpts For Growth Model With Individually Varying Times Of Observation And Random Slopes For Time-Varying Covariates (Continued)

Intercepts			
MATH7	0.000	0.000	0.000
MATH8	0.000	0.000	0.000
MATH9	0.000	0.000	0.000
MATH10	0.000	0.000	0.000
I	4.992	0.025	198.456
S	0.417	0.009	47.275
STVC	0.113	0.010	11.416
Residual Variances			
MATH7	0.185	0.011	16.464
MATH8	0.178	0.008	22.232
MATH9	0.156	0.008	18.497
MATH10	0.169	0.014	12.500
I	0.570	0.023	25.087
S	0.036	0.003	12.064
STVC	0.012	0.002	5.055

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Random Slopes

- In single-level modeling random slopes $ß_i$ describe variation across individuals i,

$$y_i = \alpha_i + ß_i\, x_i + \varepsilon_i\,, \quad (100)$$
$$\alpha_i = \alpha + \zeta_{0i}\,, \quad (101)$$
$$ß_i = ß + \zeta_{1i}\,, \quad (102)$$

Resulting in heteroscedastic residual variances

$$V\,(y_i \mid x_i) = V\,(\,ß_i\,)\;\; x_i^2 \;+ \theta \quad (103)$$

- In two-level modeling random slopes $ß_j$ describe variation across clusters j

$$y_{ij} = a_j + ß_j\; x_{ij} + \varepsilon_{ij}\,, \quad (104)$$
$$a_j = a + \zeta_{0j}\,, \quad (105)$$
$$ß_j = ß + \zeta_{1j}\,. \quad (106)$$

A small variance for a random slope typically leads to slow convergence of the ML-EM iterations. This suggests respecifying the slope as fixed.

Mplus allows random slopes for predictors that are

- Observed covariates
- Observed dependent variables
- Continuous latent variables

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Computational Issues For Growth Models

- Decreasing variances of the observed variables over time may make the modeling more difficult
- Scale of observed variables – keep on a similar scale
- Convergence – often related to starting values or the type of model being estimated
  - Program stops because maximum number of iterations has been reached
    - If no negative residual variances, either increase the number of iterations or use the preliminary parameter estimates as starting values
    - If there are large negative residual variances, try better starting values
  - Program stops before the maximum number of iterations has been reached
    - Check if variables are on a similar scale
    - Try new starting values
- Starting values – the most important parameters to give starting values to are residual variances and the intercept growth factor mean
- Convergence for models using the | symbol
  - Non-convergence may be caused by zero random slope variances which indicates that the slopes should be fixed rather than random

118

Advanced Growth Models

119

Advantages Of Growth Modeling In A Latent Variable Framework

- Flexible curve shape
- Individually-varying times of observation
- **Regressions among random effects**
- Multiple processes
- Modeling of zeroes
- Multiple populations
- Multiple indicators
- Embedded growth models
- Categorical latent variables: growth mixtures

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Regressions Among Random Effects

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Regressions Among Random Effects

Standard multilevel model (where $x_t = 0, 1, \ldots, T$):

$$\textit{Level 1}: y_{ti} = \eta_{0i} + \eta_{1i}\, x_t + \varepsilon_{ti}\,, \quad (1)$$

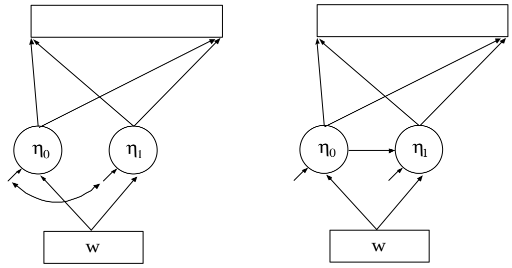
$$\textit{Level 2a}: \eta_{0i} = \alpha_0 + \gamma_0\, w_i + \zeta_{0i}\,, \quad (2)$$

$$\textit{Level 2b}: \eta_{1i} = \alpha_1 + \gamma_1\, w_i + \zeta_{1i}\,. \quad (3)$$

A useful type of model extension is to replace (3) by the regression equation

$$\eta_{1i} = \alpha + \beta\, \eta_{0i} + \gamma\, w_i + \zeta_i\,. \quad (4)$$

Example: Blood Pressure (Bloomqvist, 1977)



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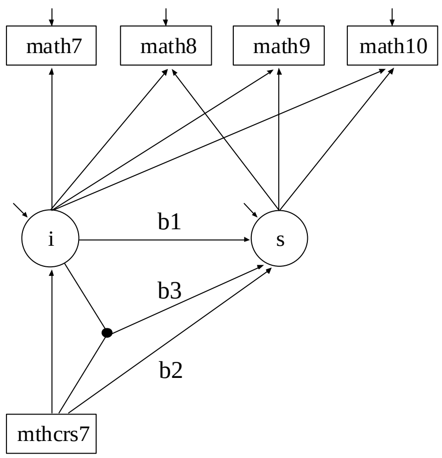
Growth Model With An Interaction



123

Input For A Growth Model With An Interaction Between A Latent And An Observed Variable

```
TITLE:     growth model with an interaction between a latent and an
           observed variable
DATA:      FILE IS lsay.dat;
VARIABLE:  NAMES ARE math7 math8 math9 math10 mthcrs7;
           MISSING ARE ALL (9999);
           CENTERING = GRANDMEAN (mthcrs7);
DEFINE:    math7 = math7/10;
           math8 = math8/10;
           math9 = math9/10;
           math10 = math10/10;
ANALYSIS:  TYPE=RANDOM MISSING;
MODEL:     i s | math7@0 math8@1 math9@2 math10@3;
           [math7-math10] (1);     !growth language defaults
           [i@0 s];                !overridden

           inter | i XWITH mthcrs7;
           s ON i mthcrs7 inter;
           i ON mthcrs7;
OUTPUT:    SAMPSTAT STANDARDIZED TECH1 TECH8;
```

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Output Excerpts Growth Model With An Interaction Between A Latent And An Observed Variable

Tests Of Model Fit

```
Loglikelihood

          H0 Value                              -10068.944
Information Criteria

          Number of Free Parameters                     12
          Akaike (AIC)                           20161.887
          Bayesian (BIC)                         20234.365
          Sample-Size Adjusted BIC               20196.236
            (n* = (n + 2) / 24)
```

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Output Excerpts Growth Model With An Interaction Between A Latent And An Observed Variable (Continued)

Model Results

```
                  Estimates      S.E.  Est./S.E.
 I        |
    MATH7             1.000     0.000     0.000
    MATH8             1.000     0.000     0.000
    MATH9             1.000     0.000     0.000
    MATH10            1.000     0.000     0.000
 S        |
    MATH7             0.000     0.000     0.000
    MATH8             1.000     0.000     0.000
    MATH9             2.000     0.000     0.000
    MATH10            3.000     0.000     0.000
```

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Output Excerpts Growth Model With An Interaction Between A Latent And An Observed Variable (Continued)

	Estimates	S.E.	Est./S.E.
S ON			
I	0.087	0.012	7.023
INTER	-0.047	0.006	-7.301
S ON			
MTHCRS7	0.045	0.013	3.555
I ON			
MTHCRS7	0.632	0.016	40.412

Output Excerpts Growth Model With An Interaction Between A Latent And An Observed Variable (Continued)

	Estimates	S.E.	Est./S.E.
Intercepts			
MATH7	5.019	0.015	341.587
MATH8	5.019	0.015	341.587
MATH9	5.019	0.015	341.587
MATH10	5.019	0.015	341.587
I	0.000	0.000	0.000
S	0.417	0.007	57.749
Residual Variances			
MATH7	0.184	0.011	16.117
MATH8	0.178	0.009	20.109
MATH9	0.164	0.009	18.369
MATH10	0.173	0.015	11.509
I	0.528	0.018	28.935
S	0.037	0.004	10.027

Interpreting The Effect Of The Interaction Between Initial Status Of Growth In Math Achievement And Course Taking In Grade 6

- Model equation for slope s
  s = a + b1*i + b2*mthcrs7 + b3*i*mthcrs7 + e

  or, using a moderator function (Klein & Moosbrugger, 2000) where i moderates the influence of mthcrs7 on s
  s = a + b1*i + (b2 + b3*i)*mthcrs7 + e

- Estimated model

  Unstandardized
  s = 0.417 + 0.087*i + (0.045 – 0.047*i)*mthcrs7

  Standardized with respect to i and mthcrs7
  s = 0.42 + 0.08 * i + (0.04-0.04*i)*mthcrs7

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Interpreting The Effect Of The Interaction Between Initial Status Of Growth In Math Achievement And Course Taking In Grade 6 (Continued)

- Interpretation of the standardized solution
  At the mean of i, which is zero, the slope increases 0.04 for 1 SD increase in mthcrs7

  At 1 SD below the mean of i, which is zero, the slope increases 0.08 for 1 SD increase in mthcrs7

  At 1 SD above the mean of i, which is zero, the slope does not increase as a function of mthcrs7

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Growth Modeling With Parallel Processes

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Advantages Of Growth Modeling In A Latent Variable Framework

- Flexible curve shape
- Individually-varying times of observation
- Regressions among random effects
- **Multiple processes**
- Modeling of zeroes
- Multiple populations
- Multiple indicators
- Embedded growth models
- Categorical latent variables: growth mixtures

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Multiple Processes

- Parallel processes
- Sequential processes

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Growth Modeling With Parallel Processes

- Estimate a growth model for each process separately
  - Determine the shape of the growth curve
  - Fit model without covariates
  - Modify the model
- Joint analysis of both processes
- Add covariates

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LSAY Data

The data come from the Longitudinal Study of American Youth (LSAY). Two cohorts were measured at four time points beginning in 1987. Cohort 1 was measured in Grades 10, 11, and 12. Cohort 2 was measured in Grades 7, 8, 9, and 10. Each cohort contains approximately 60 schools with approximately 60 students per school. The variables measured include math and science achievement items, math and science attitude measures, and background information from parents, teachers, and school principals. There are approximately 60 items per test with partial item overlap across grades—adaptive tests.

Data for the analysis include the younger females. The variables include math achievement and math attitudes from Grades 7, 8, 9, and 10 and mother's education.

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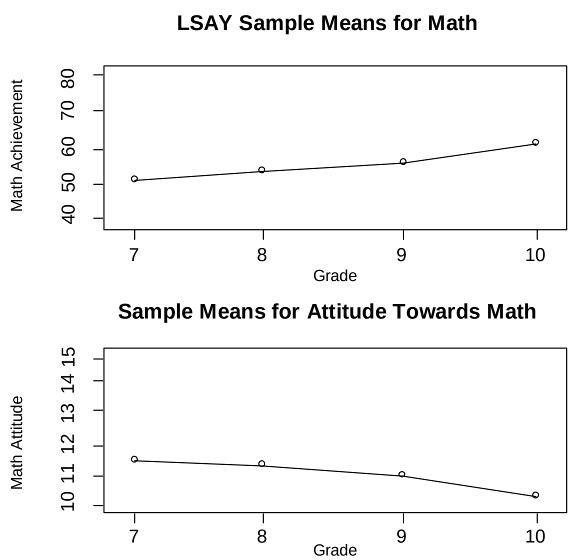

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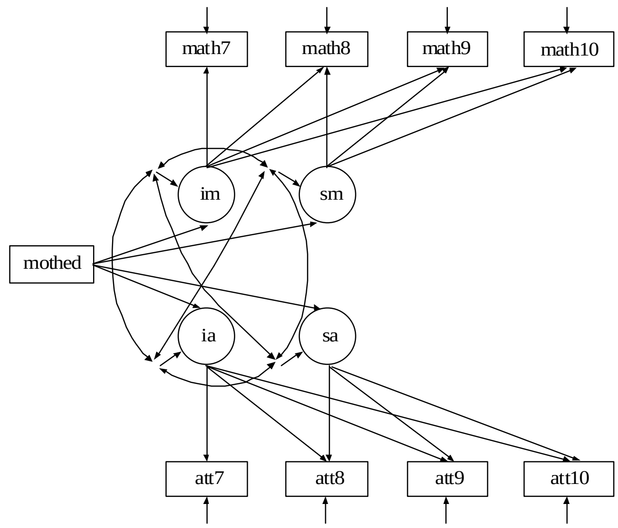

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Input For LSAY Parallel Process Growth Model

```
TITLE:      LSAY For Younger Females With Listwise Deletion
            Parallel Process Growth Model-Math Achievement and
            Math Attitudes

DATA:       FILE IS lsay.dat;
            FORMAT IS 3f8 f8.4 8f8.2 3f8 2f8.2;

VARIABLE:   NAMES ARE cohort id school weight math7 math8 math9
            math10 att7 att8 att9 att10 gender mothed homeres
            ses3 sesq3;
            USEOBS = (gender EQ 1 AND cohort EQ 2);
            MISSING = ALL (999);
            USEVAR = math7-math10 att7-att10 mothed;

ANALYSIS:   TYPE = MEANSTRUCTURE;
```

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Input For LSAY Parallel Process Growth Model

```
MODEL:     im sm | math7@0 math8@1 math9 math10;
           ia sa | att7@0 att8@1 att9@2 att10@3;
           im-sa ON mothed;

OUTPUT:    MODINDICES STANDARDIZED;
```

Alternative language:

```
           im BY math7-math10@1;
           sm BY math7@0 math8@1 math9 math10;

           ia BY att7-att10@1;
           sa BY att7@0 att8@1 att9@2 att10@3;

           [math7-math10@0 att7-att10@0];
           [im sm ia sa];

           im-sa ON mothed;
```

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Output Excerpts LSAY Parallel Process Growth Model

n = 910

Tests of Model Fit

```
Chi-Square Test of Model Fit

          Value                        43.161
          Degrees of Freedom               24
          P-Value                       .0095

RMSEA (Root Mean Square Error Of Approximation)

          Estimate                       .030
          90 Percent C.I.                .015   .044
          Probability RMSEA <= .05       .992
```

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Output Excerpts LSAY Parallel Process Growth Model (Continued)

	Estimates	S.E.	Est./S.E.	Std	StdYX
IM ON					
MOTHED	**2.462**	**.280**	**8.798**	**.311**	**.303**
SM ON					
MOTHED	**.145**	**.066**	**2.195**	**.132**	**.129**
IA ON					
MOTHED	**.053**	**.086**	**.614**	**.025**	**.024**
SA ON					
MOTHED	**.012**	**.035**	**.346**	**.017**	**.017**

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Output Excerpts LSAY Parallel Process Growth Model (Continued)

	Estimates	S.E.	Est./S.E.	Std	StdYX
SM WITH					
IM	3.032	.580	5.224	.350	.350
IA WITH					
IM	4.733	.702	6.738	.282	.282
SM	.544	.164	3.312	.235	.235
SA WITH					
IM	-.276	.279	-.987	-.049	-.049
SM	.130	.066	1.976	.168	.168
IA	-.567	.115	-4.913	-.378	-.378

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Modeling With Zeroes

143

Advantages Of Growth Modeling In A Latent Variable Framework

- Flexible curve shape
- Individually-varying times of observation
- Regressions among random effects
- Multiple processes
- **Modeling of zeroes**
- Multiple populations
- Multiple indicators
- Embedded growth models
- Categorical latent variables: growth mixtures

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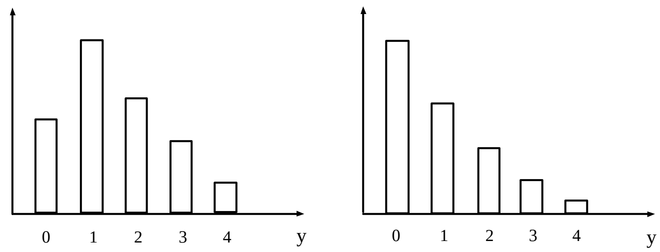
Modeling With A Preponderance Of Zeros



- Outcomes: non-normal continuous – count – categorical
- Censored-normal modeling
- Two-part (semicontinuous modeling): Duan et al. (1983), Olsen & Schafer (2001)
- Mixture models, e.g. zero-inflated (mixture) Poisson (Roeder et al., 1999), censored-inflated, mover-stayer latent transition models, growth mixture models
- Onset (survival) followed by growth: Albert & Shih (2003)

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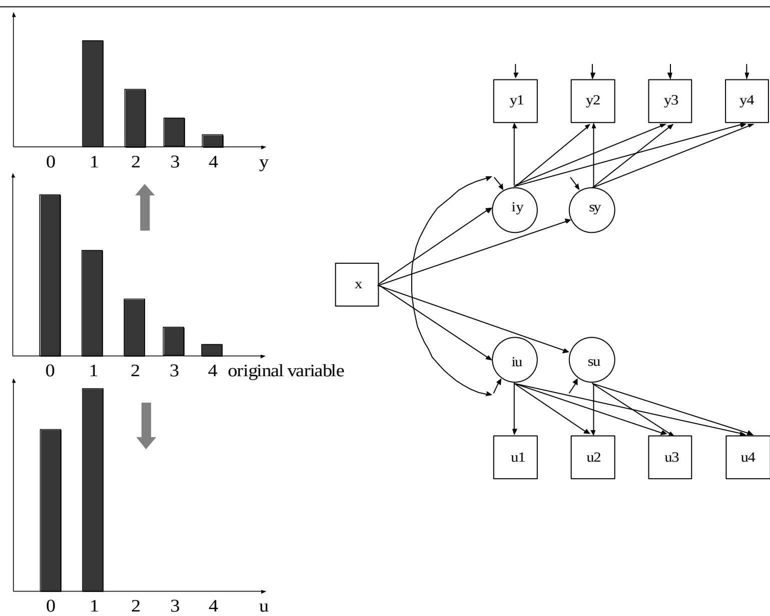
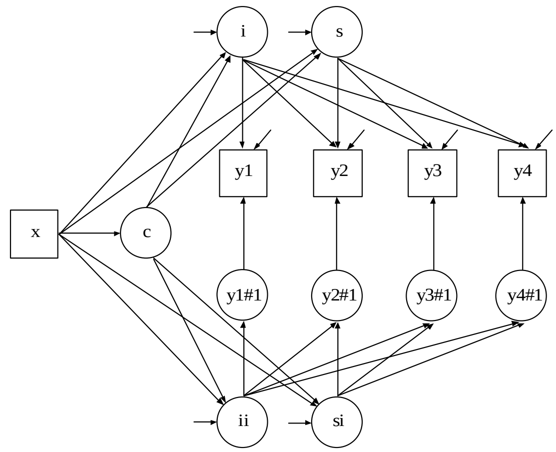
Two-Part (Semicontinuous) Growth Modeling



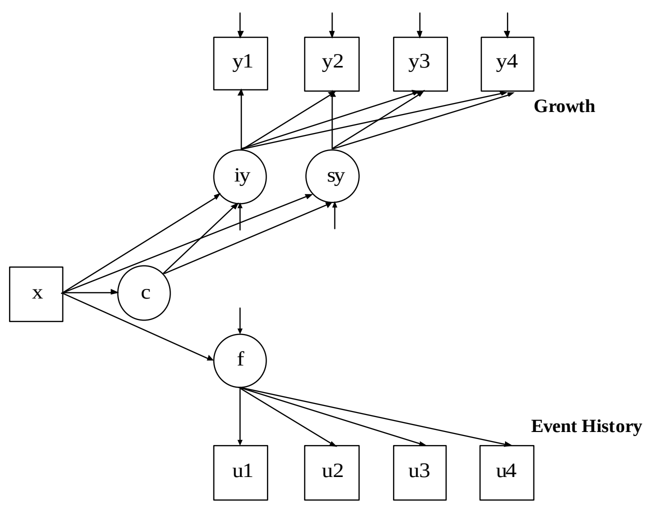
146

Inflated Growth Modeling (Two Classes At Each Time Point)



147

Onset (Survival) Followed By Growth



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Two-Part Growth Modeling

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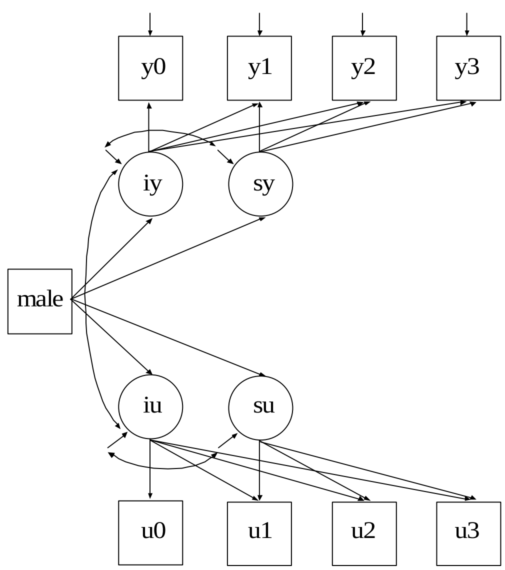

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Input For Step 1 Of A Two-Part Growth Model

```
TITLE:      step 1 of a two-part growth model
               Amover u    y
                >0    1   >0
                 0    0   999
                999  999  999
DATA:       FILE = amp.dat;
VARIABLE:   NAMES ARE caseid
            amover0 ovrdrnk0 illdrnk0 vrydrn0
            amover1 ovrdrnk1 illdrnk1 vrydrn1
            amover2 ovrdrnk2 illdrnk2 vrydrn2
            amover3 ovrdrnk3 illdrnk3 vrydrn3
            amover4 ovrdrnk4 illdrnk4 vrydrn4
            amover5 ovrdrnk5 illdrnk5 vrydrn5
            amover6 ovrdrnk6 illdrnk6 vrydrn6
            tfq0-tfq6 v2 sex race livewith
            agedrnk0-agedrnk6 grades0-grades6;
            USEV = amover0 amover1 amover2 amover3
            sex race u0-u3 y0-y3;
          ! MISSING = ALL (999);
```

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Input For Step 1 Of A Two-Part Growth Model (Continued)

```
DEFINE:       u0 = 1;                                 !binary part of variable
              IF(amover0 eq 0) THEN u0 = 0;
              IF(amover0 eq 999) THEN u0 = 999;
              y0 = amover0;                           !continuous part of variable
              IF (amover0 eq 0) THEN y0 = 999;
              u1 = 1;
              IF(amover1 eq 0) THEN u1 = 0;
              IF(amover1 eq 999) THEN u1 = 999:
              y1 = amover1;
              IF(amover1 eq 0) THEN y1 = 999;
              u2 = 1;
              IF(amover2 eq 0) THEN u2 = 0;
              IF(amover2 eq 999) THEN u2 = 999;
              y2 = amover2;
              IF(amover2 eq 0) THEN y2 = 999;
              u3 = 1;
              IF(amover3 eq 0) THEN u3 = 0;
              IF(amover3 eq 999) THEN u3 = 999;
              y3 = amover3;
              IF(amover3 eq 0) THEN y3 = 999;
ANALYSIS:     TYPE = BASIC;
SAVEDATA:     FILE = ampyu.dat;
```

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Output Excerpts Step 1 Of A Two-Part Growth Model

SAVEDATA Information

```
Order and format of variables
    AMOVER0  F10.3
    AMOVER1  F10.3
    AMOVER2  F10.3
    AMOVER3  F10.3
    SEX      F10.3
    RACE     F10.3
    U0       F10.3
    U1       F10.3
    U2       F10.3
    U3       F10.3
    Y0       F10.3
    Y1       F10.3
    Y2       F10.3
    Y3       F10.3
Save file
     ampyu.dat
Save file format
     14F10.3
Save file record length    1000
```

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Input For Step 2 Of A Two-Part Growth Model

```
TITLE:      two-part growth model with linear growth for both
            parts
DATA:       FILE = ampyau.dat;
VARIABLE:   NAMES = amover0-amover3 sex race u0-u3 y0-y3;
            USEV = u0-u3 y0-y3 male;
            USEOBS = u0 NE 999;
            MISSING = ALL (999);
            CATEGORICAL = u0-u3;
DEFINE:     male = 2-sex;
```

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Input For Step 2 Of A Two-Part Growth Model (Continued)

```
ANALYSIS:  TYPE = MISSING;
           ESTIMATOR = ML;
           ALGORITHM = INTEGRATION;
           COVERAGE = .09;
MODEL:     iu su | u0@0 u1@0.5 u2@1.5 u3@2.5;
           iy sy | y0@0 y1@0.5 y2@1.5 y3@2.5;
           iu-sy ON male;
           ! estimate the residual covariances
           ! iu with su, iy with sy, and iu with iy
           iu WITH sy@0;
           su WITH iy-sy@0;
OUTPUT:    PATTERNS SAMPSTAT STANDARDIZED TECH1 TECH4 TECH8;
PLOT:      TYPE = PLOT3;
           SERIES = u0-u3(su) | y0-y3(sy);
```

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Output Excerpts Step 2 Of A Two-Part Growth Model

Tests of Model Fit

```
Loglikelihood

          H0 Value                    -3277.101

Information Criteria

          Number of Free parameters          19
          Akaike (AIC)                 6592.202
          Bayesian (BIC)               6689.444
          Sample-Size Adjusted BIC     6629.092
             (n* = (n + 2) / 24)
```

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Output Excerpts Step 2 Of A Two-Part Growth Model (Continued)

Model Results

	Estimates	S.E.	Est./S.E.	Std	StdYX
IU |					
U0	1.000	0.000	0.000	2.839	0.843
U1	1.000	0.000	0.000	2.839	0.882
U2	1.000	0.000	0.000	2.839	0.926
U3	1.000	0.000	0.000	2.839	0.905
SU |					
U0	0.000	0.000	0.000	0.000	0.000
U1	0.500	0.000	0.000	0.416	0.129
U2	1.500	0.000	0.000	1.249	0.407
U3	2.500	0.000	0.000	2.082	0.664

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Output Excerpts Step 2 Of A Two-Part Growth Model (Continued)

IY |					
Y0	1.000	0.000	0.000	0.534	0.787
Y1	1.000	0.000	0.000	0.534	0.738
Y2	1.000	0.000	0.000	0.534	0.740
Y3	1.000	0.000	0.000	0.534	0.644
SY |					
Y0	0.000	0.000	0.000	0.000	0.000
Y1	0.500	0.000	0.000	0.117	0.162
Y2	1.500	0.000	0.000	0.351	0.487
Y3	2.500	0.000	0.000	0.586	0.707

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Output Excerpts Step 2 Of A Two-Part Growth Model (Continued)

```
 IU       ON
    MALE          0.569   0.234     2.433    0.200    0.100
 SU       ON
    MALE         -0.181   0.119    -1.518   -0.218   -0.109
 IY       ON
    MALE          0.149   0.061     2.456    0.279    0.139
 SY       ON
    MALE         -0.068   0.038    -1.790   -0.290   -0.145

 IU       WITH
    SU           -1.144   0.326    -3.509   -0.484   -0.484
    IY            1.193   0.134     8.897    0.788    0.788
    SY            0.000   0.000     0.000    0.000    0.000
 IY       WITH
    SY           -0.039   0.019    -2.109   -0.316   -0.316
 SU       WITH
    IY            0.000   0.000     0.000    0.000    0.000
    SY            0.000   0.000     0.000    0.000    0.000
```

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Output Excerpts Step 2 Of A Two-Part Growth Model (Continued)

```
Intercepts
   Y0                0.000   0.000    0.000    0.000     0.000
   Y1                0.000   0.000    0.000    0.000     0.000
   Y2                0.000   0.000    0.000    0.000     0.000
   Y3                0.000   0.000    0.000    0.000     0.000
   IU                0.000   0.000    0.000    0.000     0.000
   SU                0.855   0.098    8.716    1.027     1.027
   IY                0.232   0.059    3.901    0.435     0.435
   SY                0.240   0.031    7.830    1.025     1.025

Thresholds
   U0$1              2.655   0.206   12.877
   U1$1              2.655   0.206   12.877
   U2$1              2.655   0.206   12.877
   U3$1              2.655   0.206   12.877
```

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Output Excerpts Step 2 Of A Two-Part Growth Model (Continued)

Residual Variances

Y0	0.175	0.032	5.470	0.175	0.380
Y1	0.266	0.029	9.159	0.266	0.509
Y2	0.238	0.027	8.810	0.238	0.457
Y3	0.269	0.054	5.014	0.269	0.392
IU	7.982	1.086	7.351	0.990	0.990
SU	0.685	0.202	3.400	0.988	0.988
IY	0.279	0.040	7.019	0.981	0.981
SY	0.054	0.017	3.224	0.979	0.979

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Output Excerpts Step 2 Of A Two-Part Growth Model (Continued)

Observed Variable	R-Square
U0	0.710
U1	0.682
U2	0.650
U3	0.666
Y0	0.620
Y1	0.491
Y2	0.543
Y3	0.608

Latent Variable	R-Square
IU	0.010
SU	0.012
IY	0.019
SY	0.021

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Output Excerpts Step 2 Of A Two-Part Growth Model (Continued)

Technical 4 Output

ESTIMATED MEANS FOR THE LATENT VARIABLES

	IU	SU	IY	SY	MALE
1	0.305	0.758	0.312	0.204	0.536

ESTIMATED COVARIANCE MATRIX FOR THE LATENT VARIABLES

	IU	SU	IY	SY	MALE
IU	8.062				
SU	-1.170	0.694			
IY	1.214	-0.007	0.285		
SY	-0.010	0.003	-0.042	0.055	
MALE	0.142	-0.045	0.037	-0.017	0.249

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Output Excerpts Step 2 Of A Two-Part Growth Model (Continued)

ESTIMATED CORRELATION MATRIX FOR THE LATENT VARIABLES

	IU	SU	IY	SY	MALE
IU	1.000				
SU	-0.495	1.000			
IY	0.801	-0.015	1.000		
SY	-0.014	0.016	-0.336	1.000	
MALE	0.100	-0.109	0.139	-0.145	1.000

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