

Technical Appendix to Accompany

General Growth Modeling in Experimental Designs:  
A Latent Variable Framework for  
Analysis and Power Estimation

by

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Part 1. LISCOMP program for hypothetical growth model presented in Figure 1 of Muthén and Curran (1996). The first five '?'s correspond to the five repeated measures, the sixth '?' corresponds to the time-invariant covariate *W*, and the last three '?'s correspond to the three time-variant covariates *V*.

TI HYPOTHETICAL GROWTH MODEL CORRESPONDING TO FIGURE 1 IN MUTHÉN & CURRAN (1996)  
TI FIVE TIME POINTS WITH INTERCEPT AND LINEAR SLOPE GROWTH FACTORS  
TI ONE TIME INVARIANT 'W' AND THREE TIME VARYING 'V's  
TI EQUALITY CONSTRAINTS OF REPEATED MEASURES IMPOSED IN NU  
DA IY=9 IX=0 NO=250

LA

'Y1' 'Y2' 'Y3' 'Y4' 'Y5' 'W' 'V3' 'V4' 'V5'

MO MO=SE P1 P3 NE=11 LY=FI TE=FI BE=FI PS=FI NU=FI AL=FI

VA 1.0 LY(1,1) LY(2,2) LY(3,3) LY(4,4) LY(5,5) LY(6,6) LY(7,7) LY(8,8) LY(9,9)

VA 1.0 BE(1,10) BE(2,10) BE(3,10) BE(4,10) BE(5,10)

VA 0.0 BE(1,11)

VA 1.0 BE(2,11)

VA 2.0 BE(3,11)

VA 3.0 BE(4,11)

VA 4.0 BE(5,11)

FR PS(1,1) PS(2,2) PS(3,3) PS(4,4) PS(5,5) PS(6,6) PS(7,7) PS(8,8) PS(9,9) PS(10,10) PS(11,11) PS(11,10)

FR PS(9,8) PS(9,7) PS(9,6) PS(8,7) PS(8,6) PS(7,6)

FR NU(1) NU(2) NU(3) NU(4) NU(5)

FR AL(6) AL(7) AL(8) AL(9)

EQ NU(1,1) NU(1,2)

EQ NU(1,1) NU(1,3)

EQ NU(1,1) NU(1,4)

EQ NU(1,1) NU(1,5)

FR AL(11)

FR BE(10,6) BE(11,6) BE(3,7) BE(4,8) BE(5,9)

VA 1.00 PS(1,1)

VA 1.00 PS(2,2)

VA 1.00 PS(3,3)

VA 1.00 PS(4,4)

VA 1.00 PS(5,5)

VA 1.00 PS(6,6)

VA 1.00 PS(7,7)

VA 1.00 PS(8,8)

VA 1.00 PS(9,9)

VA 1.00 PS(10,10)

VA 1.00 PS(11,11)

VA 0.25 PS(11,10)

VA 1.0 NU(1) NU(2) NU(3) NU(4) NU(5)

VA 0.0 AL(10)

VA 1.0 AL(11)

OU MN ST RS ES ET PT SE TV

SC

(enter data here)

Part 2. SAS programs for computing power estimates.

A. Sample SAS program to compute a single power estimate as a function of degrees of freedom (DF),  $\alpha=0.05$  (CRIT), sample size (N), and the minimum of the fit function obtained using the Satorra-Saris method (FCN).

```
DATA POWER;
DF=1; CRIT=3.841459; FCN=.xx;
LAMBDA=(N-1)*FCN;
POWER=(1-(PROBCHI(CRIT,DF,LAMBDA)));
RUN;
```

B. Sample SAS program to compute a range of power estimates varying as a function of sample size that are then read to an outfile for generating power curves.

```
DATA POWER;
DF=1; CRIT=3.841459; FCN=.xx;
DO N=100 TO 1000;
LAMBDA=(N-1)*FCN;
POWER=(1-(PROBCHI(CRIT,DF,LAMBDA)));
OUTPUT;
N=N+24;
END;
RUN;
DATA _NULL_;
SET POWER; FILE OUT;
PUT N 1-5 .0 POWER 7-14 .7;
RUN;
```

Part 3. LISCOMP program for modeling the first artificial data example in which there is a main effect of treatment, but no interaction between treatment and initial status. The mean vectors (given with negative signs) and the covariance matrices are given after the "SC" command for each group (the control group is presented first, followed by the treatment group). The first five ?'s correspond to the five repeated measures, the sixth ? is the normative intercept, the seventh ? is the normative slope, and the eighth ? is the treatment slope.

```

TI FIVE TIME POINTS: ALPHA(C) BETA(C) AND BETA(T)
TI EQUALITY CONSTRAINT IN NU, NOT ALPHA
TI MEAN OF BETA(T)=.183, ES=.20
TI GROUP 1 IS CONTROL, GROUP 2 IS TREATMENT
DA IY=5 IX=0 NG=2 NO=250
LA
'T1' 'T2' 'T3' 'T4' 'T5'
MO MO=SE P1 P3 NE=8 LY=FI TE=FI BE=FI PS=FI NU=FI AL=FI
VA 1.0 LY(1,1) LY(2,2) LY(3,3) LY(4,4) LY(5,5)
VA 1.0 BE(1,6) BE(2,6) BE(3,6) BE(4,6) BE(5,6)
VA 0.0 BE(1,7)
VA 1.0 BE(2,7)
VA 2.0 BE(3,7)
VA 3.0 BE(4,7)
VA 4.0 BE(5,7)
FR PS(1,1) PS(2,2) PS(3,3) PS(4,4) PS(5,5) PS(6,6) PS(7,7) PS(7,6)
FR AL(7)
FR NU(1) NU(2) NU(3) NU(4) NU(5)
EQ NU(1,1) NU(1,2)
EQ NU(1,1) NU(1,3)
EQ NU(1,1) NU(1,4)
EQ NU(1,1) NU(1,5)
VA 1.00 PS(1,1)
VA 1.42 PS(2,2)
VA 2.27 PS(3,3)
VA 3.47 PS(4,4)
VA 5.09 PS(5,5)
VA 1.00 PS(6,6)
VA 0.20 PS(7,7)
VA 0 PS(8,8)
VA 0.11 PS(7,6)
VA 0.00 AL(6)
VA 0.79 AL(7)
VA 1.00 NU(1) NU(2) NU(3) NU(4) NU(5)
OU MN ST RS ES ET PT SE TV
SC
-1 -1.797998 -2.595996 -3.393994 -4.191992
2
1.1118034 2.8472136
1.2236068 1.7354102 4.4944272
1.3354102 2.0472136 2.759017 6.9416408
1.4472136 2.359017 3.2708204 4.1826238 10.188854

```

(continued)

TI GROUP 1 IS CONTROL, GROUP 2 IS TREATMENT  
 DA IY=5 IX=0 NG=2 NO=250  
 MO MO=SE P1 P3 NE=8 LY=FI TE=FI BE=FI PS=FI NU=FI AL=FI  
 VA 1.0 LY(1,1) LY(2,2) LY(3,3) LY(4,4) LY(5,5)  
 VA 1.0 BE(1,6) BE(2,6) BE(3,6) BE(4,6) BE(5,6)  
 VA 0.0 BE(1,7)  
 VA 1.0 BE(2,7)  
 VA 2.0 BE(3,7)  
 VA 3.0 BE(4,7)  
 VA 4.0 BE(5,7)  
 VA 0.0 BE(1,8)  
 VA 1.0 BE(2,8)  
 VA 2.0 BE(3,8)  
 VA 3.0 BE(4,8)  
 VA 4.0 BE(5,8)  
 FR PS(1,1) PS(2,2) PS(3,3) PS(4,4) PS(5,5) PS(6,6) PS(7,7) PS(7,6)  
 FR AL(7)  
 FR NU(1) NU(2) NU(3) NU(4) NU(5)  
 EQ NU(2,1) NU(2,2)  
 EQ NU(2,1) NU(2,3)  
 EQ NU(2,1) NU(2,4)  
 EQ NU(2,1) NU(2,5)  
 EQ NU(2,1) NU(1,1)  
 EQ NU(2,2) NU(1,2)  
 EQ NU(2,3) NU(1,3)  
 EQ NU(2,4) NU(1,4)  
 EQ NU(2,5) NU(1,5)  
 EQ PS(2,6,6) PS(1,6,6)  
 EQ PS(2,7,7) PS(1,7,7)  
 EQ PS(2,7,6) PS(1,7,6)  
 EQ AL(2,7) AL(1,7)  
 VA 1.00 PS(1,1)  
 VA 1.62 PS(2,2)  
 VA 3.05 PS(3,3)  
 VA 5.27 PS(4,4)  
 VA 8.30 PS(5,5)  
 VA 1.00 PS(6,6)  
 VA 0.20 PS(7,7)  
 VA 0.11 PS(7,6)  
 VA 0.79 AL(7)  
 VA 1.00 NU(1) NU(2) NU(3) NU(4) NU(5)  
 FR PS(8,8)  
 VA 0.20 PS(8,8)  
 FR AL(8)  
 VA .18 AL(8)  
 OU MN ST RS ES ET PT SE TV  
 SC  
 -1 -1.980943 -2.961886 -3.942829 -4.923772  
 2  
 1.1118034 3.2472136  
 1.2236068 2.1354102 6.0944272  
 1.3354102 2.6472136 3.959017 10.541641  
 1.4472136 3.159017 4.8708204 6.5826238 16.588854

Part 4. LISCOMP program for modeling the first artificial data example in which there is both a main effect of treatment and an interaction between treatment and initial status. The mean vectors (given with negative signs) and the covariance matrices are given after the "SC" command for each group (the control group is presented first, followed by the treatment group). The first five ?'s correspond to the five repeated measures, the sixth ? is the normative intercept, the seventh ? is the normative slope, and the eighth ? is the treatment slope.

```

TI FIVE TIME POINTS: ALPHA(C) BETA(C) AND BETA(T)
TI EQUALITY CONSTRAINT IN NU, NOT ALPHA; E(ALPHA)=0;
TI INCLUDES INTERACTION WITH GAMMA=.309 (ES=.30)
TI GROUP 1 IS CONTROL, GROUP 2 IS TREATMENT
DA IY=5 IX=0 NG=2 NO=250
LA
'T1' 'T2' 'T3' 'T4' 'T5'
MO MO=SE P1 P3 NE=8 LY=FI TE=FI BE=FI PS=FI NU=FI AL=FI
VA 1.0 LY(1,1) LY(2,2) LY(3,3) LY(4,4) LY(5,5)
VA 1.0 BE(1,6) BE(2,6) BE(3,6) BE(4,6) BE(5,6)
VA 0.0 BE(1,7)
VA 1.0 BE(2,7)
VA 2.0 BE(3,7)
VA 3.0 BE(4,7)
VA 4.0 BE(5,7)
FR PS(1,1) PS(2,2) PS(3,3) PS(4,4) PS(5,5) PS(6,6) PS(7,7) PS(7,6)
FR AL(7)
FR NU(1) NU(2) NU(3) NU(4) NU(5)
EQ NU(1,1) NU(1,2)
EQ NU(1,1) NU(1,3)
EQ NU(1,1) NU(1,4)
EQ NU(1,1) NU(1,5)
VA 1.00 PS(1,1)
VA 1.42 PS(2,2)
VA 2.27 PS(3,3)
VA 3.47 PS(4,4)
VA 5.09 PS(5,5)
VA 1.00 PS(6,6)
VA 0.20 PS(7,7)
VA 0 PS(8,8)
VA 0.11 PS(7,6)
VA 0.00 AL(6)
VA 0.79 AL(7)
VA 1.00 NU(1) NU(2) NU(3) NU(4) NU(5)
OU MN ST RS ES ET PT SE TV
SC
-1 -1.797998 -2.595996 -3.393994 -4.191992
2
1.1118034 2.8472136
1.2236068 1.7354102 4.4944272
1.3354102 2.0472136 2.759017 6.9416408
1.4472136 2.359017 3.2708204 4.1826238 10.188854

```

(continued)

TI GROUP 1 IS CONTROL, GROUP 2 IS TREATMENT  
 DA IY=5 IX=0 NG=2 NO=250  
 MO MO=SE P1 P3 NE=8 LY=FI TE=FI BE=FI PS=FI NU=FI AL=FI  
 VA 1.0 LY(1,1) LY(2,2) LY(3,3) LY(4,4) LY(5,5)  
 VA 1.0 BE(1,6) BE(2,6) BE(3,6) BE(4,6) BE(5,6)  
 VA 0.0 BE(1,7)  
 VA 1.0 BE(2,7)  
 VA 2.0 BE(3,7)  
 VA 3.0 BE(4,7)  
 VA 4.0 BE(5,7)  
 VA 0.0 BE(1,8)  
 VA 1.0 BE(2,8)  
 VA 2.0 BE(3,8)  
 VA 3.0 BE(4,8)  
 VA 4.0 BE(5,8)  
 FR PS(1,1) PS(2,2) PS(3,3) PS(4,4) PS(5,5) PS(6,6) PS(7,7) PS(7,6)  
 FR AL(7)  
 FR NU(1) NU(2) NU(3) NU(4) NU(5)  
 EQ NU(2,1) NU(2,2)  
 EQ NU(2,1) NU(2,3)  
 EQ NU(2,1) NU(2,4)  
 EQ NU(2,1) NU(2,5)  
 EQ NU(2,1) NU(1,1)  
 EQ NU(2,2) NU(1,2)  
 EQ NU(2,3) NU(1,3)  
 EQ NU(2,4) NU(1,4)  
 EQ NU(2,5) NU(1,5)  
 EQ PS(2,6,6) PS(1,6,6)  
 EQ PS(2,7,7) PS(1,7,7)  
 EQ PS(2,7,6) PS(1,7,6)  
 EQ AL(2,7) AL(1,7)  
 VA 1.00 PS(1,1)  
 VA 1.62 PS(2,2)  
 VA 3.05 PS(3,3)  
 VA 5.27 PS(4,4)  
 VA 8.30 PS(5,5)  
 VA 1.00 PS(6,6)  
 VA 0.20 PS(7,7)  
 VA 0.11 PS(7,6)  
 VA 0.79 AL(7)  
 VA 1.00 NU(1) NU(2) NU(3) NU(4) NU(5)  
 FR AL(8)  
 VA 0.18 AL(8)  
 FR PS(8,8)  
 VA 0.20 PS(8,8)  
 FR BE(8,6)  
 VA .309 BE(8,6)  
 OU MN ST RS ES ET PT SE TV  
 SC  
 -1 -1.980943 -2.961886 -3.942829 -4.923772  
 2  
 1.4207534 4.6211804  
 1.8415068 3.200427 9.1186946  
 2.2622602 4.0902639 5.9182675 15.492542  
 2.6830136 4.9801007 7.2771878 9.5742749 23.742724

Part 5. LISCOMP code for the final growth model of the Kellam et al. (1994) aggressive behavior intervention. The mean vectors (given with negative signs) and the covariance matrices are given after the "SC" command for each group (the control group is presented first, followed by the treatment group). The first eight ?'s correspond to the eight repeated measures, the ninth ? is the normative intercept, the tenth ? is the normative linear slope, the eleventh ? is the normative quadratic component, and the twelfth ? is the treatment linear component. It is important to note that, because of the data imputation techniques used for the analyses, these data are not necessarily reflective of the complete data set of Kellam et al. (1994). The imputation was done for demonstration purposes only.

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TI IMPUTED AGGRESSION DATA;
TI GROUP 1 = CONTROL, N=111;
TI GROUP 2 = TREATMENT, N=75;
TI ALPHA(C) BETA-LINEAR-C
TI BETA-QUAD-C AND BETA-LIN-T
DA IY=8 IX=0 NG=2 NO=111
LA
'T1' 'T2' 'T3' 'T4' 'T5' 'T6' 'T7' 'T8'
MO MO=SE P1 P3 NE=12 LY=FI TE=FI BE=FI PS=FI NU=FI AL=FI
VA 1.0 LY(1,1) LY(2,2) LY(3,3) LY(4,4) LY(5,5) LY(6,6) LY(7,7) LY(8,8)
VA 1.0 BE(1,9) BE(2,9) BE(3,9) BE(4,9) BE(5,9) BE(6,9) BE(7,9) BE(8,9)
VA 0.0 BE(1,10)
VA 1.0 BE(2,10)
VA 2.0 BE(3,10)
VA 3.0 BE(4,10)
VA 5.0 BE(5,10)
VA 7.0 BE(6,10)
VA 9.0 BE(7,10)
VA 11 BE(8,10)
VA 0.0 BE(1,11)
VA 1.0 BE(2,11)
VA 4.0 BE(3,11)
VA 9.0 BE(4,11)
VA 25 BE(5,11)
VA 49 BE(6,11)
VA 81 BE(7,11)
VA 121 BE(8,11)
FR PS(1,1) PS(2,2) PS(3,3) PS(4,4) PS(5,5) PS(6,6) PS(7,7) PS(8,8)
FR PS(9,9) PS(10,10) PS(10,9)
FR PS(2,1) PS(3,2) PS(4,3) PS(5,4) PS(6,5) PS(7,6) PS(8,7)
FR NU(1) NU(2) NU(3) NU(4) NU(5) NU(6) NU(7) NU(8)
EQ NU(1,1) NU(1,2)
EQ NU(1,1) NU(1,3)
EQ NU(1,1) NU(1,4)
EQ NU(1,1) NU(1,5)
EQ NU(1,1) NU(1,6)
EQ NU(1,1) NU(1,7)
EQ NU(1,1) NU(1,8)
FR AL(10) AL(11)
VA .449 PS(1,1)

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(continued)

VA .440 PS(2,2)  
 VA .411 PS(3,3)  
 VA .535 PS(4,4)  
 VA .535 PS(5,5)  
 VA .413 PS(6,6)  
 VA .260 PS(7,7)  
 VA .309 PS(8,8)  
 VA .737 PS(9,9)  
 VA .004 PS(10,10)  
 VA 0 PS(11,11)  
 VA 0 PS(12,12)  
 VA -.01 PS(10,9)  
 VA .280 PS(2,1)  
 VA .077 PS(3,2)  
 VA .251 PS(4,3)  
 VA .145 PS(5,4)  
 VA -.005 PS(6,5)  
 VA .052 PS(7,6)  
 VA -.107 PS(8,7)  
 VA 2.104 NU(1) NU(2) NU(3) NU(4) NU(5) NU(6) NU(7) NU(8)  
 VA .00 AL(9)  
 VA .01 AL(10)  
 VA -.01 AL(11)  
 VA 0 PS(12,12)  
 OU MN ST RS ES PT SE TV ET  
 SC  
 -1.952 -2.061 -1.984 -2.190 -2.307 -2.213 -2.318 -2.256  
 1.026  
 0.852 1.002  
 0.632 0.697 1.111  
 0.572 0.561 0.959 1.226  
 0.554 0.609 0.783 0.885 1.321  
 0.613 0.601 0.690 0.713 0.811 1.251  
 0.680 0.690 0.792 0.791 0.907 1.007 1.353  
 0.530 0.539 0.779 0.852 0.947 0.967 1.021 1.490  
 TI GROUP 1 IS CONTROL, GROUP 2 IS TREATMENT  
 DA IY=8 IX=0 NG=2 NO=75  
 MO MO=SE P1 P3 NE=12 LY=FI TE=FI BE=FI PS=FI NU=FI AL=FI  
 VA 1.0 LY(1,1) LY(2,2) LY(3,3) LY(4,4) LY(5,5) LY(6,6) LY(7,7) LY(8,8)  
 VA 1.0 BE(1,9) BE(2,9) BE(3,9) BE(4,9) BE(5,9) BE(6,9) BE(7,9) BE(8,9)  
 VA 0.0 BE(1,10)  
 VA 1.0 BE(2,10)  
 VA 2.0 BE(3,10)  
 VA 3.0 BE(4,10)  
 VA 5.0 BE(5,10)  
 VA 7.0 BE(6,10)  
 VA 9.0 BE(7,10)  
 VA 11. BE(8,10)  
 VA 0.0 BE(1,11)  
 VA 1.0 BE(2,11)  
 VA 4.0 BE(3,11)  
 VA 9.0 BE(4,11)  
 VA 25 BE(5,11)  
 VA 49 BE(6,11)

(continued)

VA 81 BE(7,11)  
VA 121 BE(8,11)  
VA 0.0 BE(1,12)  
VA 1.0 BE(2,12)  
VA 2.0 BE(3,12)  
VA 3.0 BE(4,12)  
VA 5.0 BE(5,12)  
VA 7.0 BE(6,12)  
VA 9.0 BE(7,12)  
VA 11 BE(8,12)  
FR PS(1,1) PS(2,2) PS(3,3) PS(4,4) PS(5,5) PS(6,6) PS(7,7) PS(8,8)  
FR PS(9,9) PS(10,10) PS(10,9)  
FR PS(2,1) PS(3,2) PS(4,3) PS(5,4) PS(6,5) PS(7,6) PS(8,7)  
FR AL(10) AL(11) AL(12)  
FR NU(1) NU(2) NU(3) NU(4) NU(5) NU(6) NU(7) NU(8)  
EQ NU(2,1) NU(2,2)  
EQ NU(2,1) NU(2,3)  
EQ NU(2,1) NU(2,4)  
EQ NU(2,1) NU(2,5)  
EQ NU(2,1) NU(2,6)  
EQ NU(2,1) NU(2,7)  
EQ NU(2,1) NU(2,8)  
EQ NU(2,1) NU(1,1)  
EQ NU(2,2) NU(1,2)  
EQ NU(2,3) NU(1,3)  
EQ NU(2,4) NU(1,4)  
EQ NU(2,5) NU(1,5)  
EQ NU(2,6) NU(1,6)  
EQ NU(2,7) NU(1,7)  
EQ NU(2,8) NU(1,8)  
VA .40 PS(1,1)  
VA .40 PS(2,2)  
VA .40 PS(3,3)  
VA .50 PS(4,4)  
VA .50 PS(5,5)  
VA .40 PS(6,6)  
VA .30 PS(7,7)  
VA .30 PS(8,8)  
VA .80 PS(9,9)  
VA .00 PS(10,10)  
VA -.10 PS(10,9)  
VA .10 PS(2,1)  
VA .10 PS(3,2)  
VA .10 PS(4,3)  
VA .10 PS(5,4)  
VA .10 PS(6,5)  
VA .10 PS(7,6)  
VA -.01 PS(8,7)  
VA 2.104 NU(1) NU(2) NU(3) NU(4) NU(5) NU(6) NU(7) NU(8)  
VA .00 AL(9)  
VA .01 AL(10)  
VA -.01 AL(11)  
VA -.05 AL(12)  
EQ AL(2,10) AL(1,10)

(continued)

EQ AL(2,11) AL(1,11)  
EQ PS(2,9,9) PS(1,9,9)  
EQ PS(2,10,10) PS(1,10,10)  
EQ PS(2,10,9) PS(1,10,9)  
VA 0 PS(11,11) PS(12,12)  
FR BE(12,9)  
VA -.01 BE(12,9)  
OU MN ST RS ES PT SE TV ET  
SC  
-2.307 -2.211 -2.268 -2.356 -2.489 -2.451 -2.304 -2.264  
1.654  
1.076 1.340  
0.982 0.821 1.274  
0.870 0.673 1.034 1.385  
0.870 0.873 0.658 0.781 1.397  
0.821 0.794 0.551 0.695 0.958 1.464  
0.481 0.503 0.548 0.563 0.461 0.585 0.817  
0.364 0.582 0.452 0.521 0.491 0.613 0.604 1.344