2022 COORDINATE & Understanding Society Summer Schools Joint Session Day 4: Structural Equation Models
Aim of the Day

• Morning
  • Extensions of panel models
    • Random intercepts
    • Random slopes
  • Structural Equation Models (SEM)
    • Growth curve models

• Afternoon
  • Practice running models on data
  • Work on research questions
Extensions of Panel Models
New terminology!

- Random coefficients = multilevel analysis/hierarchical modelling/mixed effects modelling/contextual effects models/random parameter models
  - Do not estimate all individual intercepts, only the variance of those intercepts, i.e., random intercept
  - In cases where development over time is different for each individual there is a subject*time interaction making estimation of coefficients for time possible, i.e. random slope
Random Intercepts & Slopes

• What if we are interested in knowing how much variance in our outcome is at the individual level?
  • Ex: Differences in young people’s levels of wellbeing between the age of 10 and 15
    • How much variation in level of wellbeing at age 15 is due household differences after controlling for wellbeing at age 10?

• Individual differences in initial levels (intercepts) are accounted for in the models we have spoken about, i.e., fixed or random effects+

• Use with repeated measures
  • Two levels are modelled
    • Within unit = Level 1
    • Between unit = Level 2
What are the two levels?

- Focus first on clusters, i.e., individuals within schools or households or schools in local authorities, etc.
- Level 1: Standard linear model for an individual, $i$, in cluster, $j$ (within model)
  - $y_{ij} = \beta_0 + \beta_1(X_{ij}) + \varepsilon_t$
    - $\beta$’s are fixed unknowns to be estimated with their variance
    - However, in longitudinal or panel data there are multiple individuals and the $\beta$’s can vary across those individuals
- Level 2: Varying intercepts or slopes
  - Random intercept: $\beta_{0j} = \gamma_{00} + \mu_{0j}$
  - Random slope: $\beta_{1j} = \gamma_{10} + \mu_{1j}$
What do the models look like?

- After some substitution we get
  - Random Intercepts Model: \( y_{ij} = \gamma_{00} + \beta_{1j}(X_{ij}) + u_{0j} + \varepsilon_{ij} \)
  - Random Slopes Model: \( y_{ij} = \beta_{0j} + \gamma_{10}(X_{ij}) + u_{1j} + \varepsilon_{ij} \)
  - Random Intercepts and Random Slopes Model:
    - \( y_{ij} = \gamma_{00} + \gamma_{10}(X_{ij}) + u_{0j} + u_{1j} + \varepsilon_{ij} \)

![Random Intercepts](image-a)
![Random Slopes](image-b)
![Random Intercepts & Slopes](image-c)
New definitions of Fixed and Random Effects?

• $\gamma$ are fixed effects
  • Fixed effects are parameters that are fixed at the same value across all individuals or clusters
  • Estimated using multiple regression with interaction terms

• $u$ are random effects
  • Unique to mixed/multilevel models
  • Able to estimate and test variances and covariances
  • Random effects vary across individuals or clusters
Any questions?
Example: Unemployment and Wellbeing
(I)

• Research Questions:
  • 1. What are the effects of multiple unemployment spells on well-being?
  • 2. Is adaptation or sensitisation more likely if one moves into unemployment from employment or from economic inactivity?
  • 3. Are there factors which moderate the effect of unemployment on well-being?

• BHPS Wave 1-18
Example: Unemployment and Wellbeing (II)

- Random intercept model: \( \text{GHQ-12}_{ij} = \beta_0 + \beta_1(\text{UE1})_{ij} + \beta_2(\text{UE2})_{ij} + \beta_3(\text{UE3+})_{ij} + \varepsilon_{ij} + \mu_i \)
  - \( \text{UE1-UE2} \): unemployment spells 1-3
  - \( \varepsilon_{ij} \): Random effect for individual \( i \) at measurement \( j \)
  - \( \mu_i \): Random intercept for individual \( i \)

- Between-person variables as moderators model: \( \text{GHQ-12}_{ij} = \beta_0 + \beta_1(\text{UE1})_{ij} + \beta_2(\text{UE2})_{ij} + \beta_3(\text{UE3+})_{ij} + \Sigma \gamma X_i + \Sigma \gamma X_i^*(\text{UE1})_{ij} + \Sigma \gamma X_i^*(\text{UE2})_{ij} + \Sigma \gamma X_i^*(\text{UE3+})_{ij} + \varepsilon_{ij} + \mu_i \)
  - \( \Sigma \gamma X_i \): Collection of moderators included in the study, i.e., age, gender, average annual household income, partnerships status, percentage of household unemployed, regional unemployment rate, pre-study unemployment and number of unemployment spells

Table 3. Model 1 Estimates of the Effects of Unemployment: Following Employment or Economic Inactivity

<table>
<thead>
<tr>
<th>Employment Status</th>
<th>Coefficient</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Following Employment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unemployment 1</td>
<td>1.66****</td>
<td>0.12</td>
</tr>
<tr>
<td>Unemployment 2</td>
<td>1.47****</td>
<td>0.28</td>
</tr>
<tr>
<td>Unemployment 3</td>
<td>0.58</td>
<td>0.73</td>
</tr>
<tr>
<td>Following Economic Inactivity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unemployment 1</td>
<td>0.94****</td>
<td>0.16</td>
</tr>
<tr>
<td>Unemployment 2</td>
<td>0.87*</td>
<td>0.37</td>
</tr>
<tr>
<td>Unemployment 3</td>
<td>2.52**</td>
<td>0.68</td>
</tr>
<tr>
<td>Intercept</td>
<td>8.02****</td>
<td>0.33</td>
</tr>
</tbody>
</table>

* <0.05; ** <0.01; *** <0.001; **** <0.0001

Controlled for age, gender and pre-study unemployment
### Example: Unemployment and Wellbeing (IV)

<table>
<thead>
<tr>
<th>Employment Status Following Employment</th>
<th>Coefficient</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unemployment 1</strong></td>
<td>2.36****</td>
<td>0.52</td>
</tr>
<tr>
<td>Age</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Average Annual Household Income</td>
<td>0.74</td>
<td>1.34</td>
</tr>
<tr>
<td>Percent of Household Unemployed</td>
<td>0.55</td>
<td>0.46</td>
</tr>
<tr>
<td>Regional Unemployment Rate</td>
<td>0.01</td>
<td>0.07</td>
</tr>
<tr>
<td>Partnership Status</td>
<td>-0.46</td>
<td>0.28</td>
</tr>
<tr>
<td>Pre-Study Unemployment</td>
<td>-1.08*</td>
<td>0.52</td>
</tr>
<tr>
<td>Multiple Unemployment Spells</td>
<td>-0.21</td>
<td>0.35</td>
</tr>
<tr>
<td>Gender</td>
<td>-0.37</td>
<td>0.25</td>
</tr>
<tr>
<td><strong>Unemployment 2</strong></td>
<td>0.77</td>
<td>1.23</td>
</tr>
<tr>
<td>Age</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Average Annual Household Income</td>
<td>2.03</td>
<td>2.81</td>
</tr>
<tr>
<td>Percent of Household Unemployed</td>
<td>1.15</td>
<td>1.01</td>
</tr>
<tr>
<td>Regional Unemployment Rate</td>
<td>-0.07</td>
<td>0.19</td>
</tr>
<tr>
<td>Partnership Status</td>
<td>0.22</td>
<td>0.58</td>
</tr>
<tr>
<td>Pre-Study Unemployment</td>
<td>1.86</td>
<td>0.97</td>
</tr>
<tr>
<td>Gender</td>
<td>0.07</td>
<td>0.59</td>
</tr>
<tr>
<td><strong>Unemployment 3</strong></td>
<td>5.27</td>
<td>5.15</td>
</tr>
<tr>
<td>Age</td>
<td>-0.11</td>
<td>0.08</td>
</tr>
<tr>
<td>Average Annual Household Income</td>
<td>-0.50</td>
<td>6.40</td>
</tr>
<tr>
<td>Percent of Household Unemployed</td>
<td>3.16</td>
<td>2.53</td>
</tr>
<tr>
<td>Regional Unemployment Rate</td>
<td>-0.24</td>
<td>1.48</td>
</tr>
<tr>
<td>Partnership Status</td>
<td>-0.98</td>
<td>1.59</td>
</tr>
<tr>
<td>Pre-Study Unemployment</td>
<td>-3.44</td>
<td>2.60</td>
</tr>
<tr>
<td>Gender</td>
<td>-3.46</td>
<td>1.99</td>
</tr>
</tbody>
</table>
What happens when we add time to the mix?

- Now we are going to look at time nested within individuals
  - Repeated measures or growth data, we will revisit growth models later
  - Within (Level 1) Linear: $Y_{ti} = \beta_{0i} + \beta_{1i}T_{it} + e_{ti}$ or $Y_{i} = T\beta_{i} + e_{i}$
    - Can also model polynomial functions of time: $Y_{ti} = \beta_{0i} + \beta_{1i}T_{it} + \beta_{2i}T_{it}^2 + \cdots + \beta_{pi}T_{it}^p + e_{ti}$
  - Between (Level 2):
    - Also called person-level
    - Intercept: $\beta_{0i} = \gamma_{00} + u_{0i}$
    - Slopes: $\beta_{1i} = \gamma_{10} + u_{1i}$
      - $\beta_{2i} = \gamma_{20} + u_{2i} \ldots \beta_{pi} = \gamma_{p0} + u_{pi}$
    - $\beta_{i} = Z_{i}\gamma + u_{i}$
  - Combined equation: $Y_{i} = TZ_{i}\gamma + Tu_{i} + e_{i}$
Considerations

• Centring level 1 (within) variables
  • Grand mean: subtracting overall mean from all scores
    • Ex: subtract the mean wellbeing score of all people in the sample from the individual’s mean wellbeing score
  • Group mean: subtracts cluster’s mean from each score in the cluster
    • Ex: for each individual within an ethnic group, subtract the mean wellbeing score of their ethnic group from the individuals mean wellbeing score

• Number of units can vary across clusters

• Use maximum likelihood estimation
  • Estimate parameters that maximise the probability of observing our data
    • Full information maximum likelihood (FIML): variance and covariance estimates are conditional on the point estimates of fixed effects
    • Restricted maximum likelihood (FEML): maximised joint likelihood of level 2 variance components and level 1 residual variance given the observed sample data
Model fit

• Ways to determine model fit
  • Likelihood ratio (deviance difference) test (LRT)
    • \(-2 \times (\text{log likelihood of the specified model} - \text{the log likelihood of saturated model})\)
    • Saturated model = perfectly fitted model
    • Lower values = better fit
  • Akaike Information Criterion (AIC) & Bayesian Information Criterion (BIC)
    • \(\text{AIC} = D + 2p\), where \(D\) is deviance (-2log likelihood) and \(p\) is the number of parameters
      • Lower values = better fit
      • Favours more parsimonious models than LRT
    • \(\text{BIC} = D + \ln(n) \times p\), where \(n\) is the sample size
      • Function of sample size, however calculation of sample size may differ between statistical programs
      • Favours simpler model
      • Lower values = better fit
There are several programmes you can use to analyse multilevel models:

- **Common**: Stata, R, SPSS
- **Specialised**: MLwiN, aML, EGRET, GENSTAT, GLLAMM, MIXREG, S-Plus, SYSTAT, WinBUGS, Mplus

**Resources**
- [http://www.bristol.ac.uk/cmm/](http://www.bristol.ac.uk/cmm/)
Any questions?
Break
Structural Equation Modeling (SEM)

• Used to test hypotheses about relationships, directional and nondirectional among observed (measured) and latent (unobserved) variables

• Goals
  • Understand patterns of correlation/covariance among a set of variables
  • Explain variance with specified model
How is SEM different from traditional methods?

• SEM is:
  • More flexible
  • Requires formal specification of estimated model
    • No default model
    • Few limitations on types of relations
  • Incorporates observed and unobserved variables
  • Allows researchers to recognise imperfect nature of measures
  • No straightforward tests of significance to determine group differences, relationships between variable or amount of variance explained
    • Tests for model fit
  • Addresses issues of multicollinearity
    • Multiple measures used to describe latent constructs
    • Unobserved variables represent latent constructs
  • Easy to diagram and pictorial representations can be transformed into a set of equations which are estimated simultaneously
Variance-Covariance Matrix

• Basic building block of SEM
  • Variance = variability or spread of scores
  • Covariance = Extent to which corresponding scores vary together
    • Can be zero, positive or negative

\[ \begin{bmatrix}
  \text{var}(x) & \text{cov}(x, y) \\
  \text{cov}(x, y) & \text{var}(y)
\end{bmatrix} \]

• Unstandardized version of correlation matrix
Assumptions

• Normality: assumes variables are normally distributed
• Linearity: assumes variables are linearly related to each other
• Sampling: Maximum likelihood assumes data is a simple random sample of the population
  • Assumes independence of variables but can account for non-independence
• Sample size: Requires a larger sample, ratio of subjects to model parameters should be between 10:1-20:1. Sample size of at least 200 or more are usually sufficient
• Range of values: Outliers can impact variance-covariance matrix and may bias parameter estimates
Types of Relationships

• Associations
  • Correlations, covariance

• Direct effect
  • Directional relationship between two variables

• Indirect effect
  • Effect of an independent variable on a dependent variable through one or more intervening or mediating variables
Symbols

- Measured/observed variable
- Latent construct/factor/unmeasured variable
- Direct relationship
- Covariance or correlation
Diagramming relationships

- Error associated with observed variable
- Latent variable regressed on observed variable
- Latent variable, F1, regressed onto latent variable F2. Residual error in prediction of F2 by F1
Notation

- $\mathbf{X}$: Observed exogenous variables
- $\xi$: Latent exogenous variables
- $\mathbf{Y}$: Latent endogenous variables
- $\eta$: Latent endogenous variables
- $\lambda$: Factor loadings (paths from latent to observed variables)
- $\gamma$: Paths from exogenous to endogenous variables
- $\beta$: Causal paths (paths between endogenous variables)
- $\phi$: Correlations between exogenous variables
- $\epsilon$: Measurement residuals (errors of endogenous variables)
- $\delta$: Errors of exogenous variables
- $\zeta$: Structural disturbances (latent endogenous variables)
- $\alpha$: Latent variable means
- $\nu$: Measurement intercepts
- $\theta$: Measurement residual variances
Types of SEMs

• Factor analysis
  • Exploratory: Variable reduction technique. Also used to explore underlying theoretical structure
  • Confirmatory: Explores relationships between observed and latent variables as indicators of latent factors

• Path models
  • Tests relationships between observed variables

• Growth Curve Models
  • Estimate initial levels (intercept) and rate of change (slope), structural slopes and variance
Factor Analysis Example

- Negative School-Related Events (V1)
- Negative Family-Related Events (V2)
- Positive Family-Related Events (V3)
- Negative Peer-Related Events (V4)
- Negative Personal-Related Events (V5)
- Positive Personal-Related Events (V6)

Daily Stress (F1)

- Y1C12 (V7)
- Y1C13 (V8)

Acculturative Stress (F2)
Path Model Example

Key:
- $1.96 \leq t < 3$
- $3 \leq t < 5$
- $5 \leq t < 10$
- $t \geq 10$

Social media use

Poor sleep

Online harassment

Poor self-esteem

Poor body image

Depressive symptoms
Growth Curve Example

SNS Use Age 10 → SNS Use Age 11
SNS Use Age 11 → SNS Use Age 12
SNS Use Age 12 → SNS Use Age 13
SNS Use Age 13 → SNS Use Age 14
SNS Use Age 14 → SNS Use Age 15

SNS Use Intercept

SNS Use Slope

SNS Use Quadratic

Child’s gender

Mother ethnicity: Asian

SNS Use

Intercept

SNS Use

Slope

SNS Use

Quadratic

-0.92 (0.14)

-0.11 (0.05)

0.45 (0.09)

-0.97 (0.59)

-0.07 (0.02)
Testing Model Fit

• Chi-square: amount of difference between expected and observed covariance matrices
  • Smaller values indicates better fit
    • Looking for a p-value > 0.05

• Comparative Fit Index (CFI): equal to discrepancy function adjusted for sample size
  • Ranges from 0-1, larger value indicates better fit
    • Looking for a CFI > 0.90

• Root Mean Square Error of Approximation (RMSEA): residual model
  • Ranges from 0-1, smaller value indicate better fit
    • Looking for a RMSEA ≤ 0.06
Any questions?
Growth Curve Models
Why Use Growth Curve Models?

• Allow for estimation of systematic growth or decline over time
  • Estimate initial status and growth rate
  • Should have an idea of the trajectory, i.e., shape of growth

• Can use SEM or multilevel modeling specifications

• Estimate different types including linear, polynomial and piecewise
  • Piecewise: modelling growth trajectories as a phases with different growth rates

• Requirements
  • Need at least three time points for individual linear models and four or more time points for curvilinear
Growth Curve Model: MLM Specification

- Can be estimated as a special case of random coefficient models
  - Level 1: $Y_{it} = \beta_{0i} + \beta_{1i}T_{it} + e_{it}$
  - Level 2: $\beta_{0j} = \gamma_{00} + u_{0j}$
    $\beta_{1j} = \gamma_{10} + u_{1j}$
  - Combined: $Y_{it} = \gamma_{00} + \gamma_{10}T_{it} + u_{0i} + u_{1i}T_{it} + e_{it}$
• Research Questions 1 & 2
  • 1. Do individuals return to their well-being set point after exiting unemployment? If so, how long does it take to return to that set point?

• Data: BHPS waves 1-18

• Three-piece jointed growth curve models

Growth Curve Model Example 1: MLM Specification (II)

- Model: \( Y_{ij} = t_{1ij}b_{1j} + t_{1ij}^2b_{1j} + t_{2ij}b_{2j} + t_{2ij}^2b_{2j} + t_{3ij}b_{3j} + t_{3ij}^2b_{3j} + \sum b_{nij}X_n + \varepsilon_{ij} + \mu_i \)
  - \( t = \) repeated time measures for each stage
  - \( t^2 = \) Quadratic term
Growth Curve Example 1: MLM Specification (III)

Table 2. Overall Growth Models, by Subjective Well-being Outcome and Gender

<table>
<thead>
<tr>
<th></th>
<th>GHQ</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
<td>Women</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Regression Coefficient</td>
<td>SE</td>
<td>Regression Coefficient</td>
</tr>
<tr>
<td>Intercept</td>
<td>25.43****</td>
<td>0.27</td>
<td>24.21****</td>
</tr>
<tr>
<td>Pre-Unemployment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linear</td>
<td>-0.03</td>
<td>0.09</td>
<td>-0.06</td>
</tr>
<tr>
<td>Quadratic</td>
<td>0.01</td>
<td>0.01</td>
<td>-0.00</td>
</tr>
<tr>
<td>Unemployment Spell</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linear</td>
<td>-0.28*</td>
<td>0.14</td>
<td>-0.99****</td>
</tr>
<tr>
<td>Quadratic</td>
<td>0.04</td>
<td>0.02</td>
<td>0.26**</td>
</tr>
<tr>
<td>Post-Unemployment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linear</td>
<td>0.40****</td>
<td>0.07</td>
<td>0.43****</td>
</tr>
<tr>
<td>Quadratic</td>
<td>-0.02***</td>
<td>0.00</td>
<td>-0.02***</td>
</tr>
<tr>
<td>Age</td>
<td>-0.58****</td>
<td>0.14</td>
<td>-0.24</td>
</tr>
<tr>
<td>Age Squared</td>
<td>0.60****</td>
<td>0.11</td>
<td>0.29*</td>
</tr>
<tr>
<td>Pre-Study Unemployment</td>
<td>-0.13</td>
<td>0.42</td>
<td>-0.06</td>
</tr>
<tr>
<td>Limiting Long-term Illness</td>
<td>-2.18****</td>
<td>0.20</td>
<td>-3.14****</td>
</tr>
<tr>
<td>Annual Household Income</td>
<td>0.47</td>
<td>1.28</td>
<td>-2.97*</td>
</tr>
</tbody>
</table>

* <0.05; ** <0.01; *** <0.001; **** <0.0001
Growth Curve Example 1: MLM Specification (IV)

**Men**

- Stage 1
- Stage 2
- Stage 3

**Women**

- Stage 1
- Stage 2
- Stage 3
Growth Curve Models: SEM Specification

• Use latent variables to model individual growth curves
  • Intercept and slope are latent variables

• Constrain all factor loadings
  • Intercepts are set at 1
  • Slope represent time points
Research Aims:

- The primary aim of this study is to examine changes in social media interaction and positive and negative markers of well-being with age and to determine whether any relationship exists between social media interaction and well-being trajectories.
- A secondary aim is to examine whether the social media interaction and well-being relationships and trajectories differ by gender.

Data: Understanding Society youth panel waves 1-5

Parallel Growth Curve Models

Growth Curve
Example 2:
SEM Specification (II)
<table>
<thead>
<tr>
<th></th>
<th>SDQ Total Difficulties</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Females (n=4,762)</td>
<td>Males (n=4,901)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PE</td>
<td>95% CI</td>
<td>PE</td>
<td>95% CI</td>
</tr>
<tr>
<td>Model Intercepts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Well-being Intercept</td>
<td>13.57</td>
<td>(8.86, 18.27)</td>
<td>10.44</td>
<td>(5.54, 15.34)</td>
</tr>
<tr>
<td>Well-being Slope</td>
<td>1.69</td>
<td>(0.44, 2.93)</td>
<td>0.78</td>
<td>(-0.40, 1.95)</td>
</tr>
<tr>
<td>SMI Intercept</td>
<td>0.00</td>
<td></td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>SMI Slope</td>
<td>-0.17</td>
<td>(-0.71, 0.36)</td>
<td>0.11</td>
<td>(-0.46, 0.68)</td>
</tr>
<tr>
<td>Growth Factor Associations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Path A: Intercept SMI &lt;-- Intercept WB</td>
<td>0.18</td>
<td>(0.08, 0.27)</td>
<td>0.10</td>
<td>(0.01, 0.19)</td>
</tr>
<tr>
<td>Path B: Slope SMI &lt;-- Slope WB</td>
<td>0.26</td>
<td>(0.09, 0.43)</td>
<td>0.17</td>
<td>(-0.03, 0.36)</td>
</tr>
<tr>
<td>Path C: Slope SMI &lt;-- Intercept SMI</td>
<td>-0.08</td>
<td>(-0.13, -0.04)</td>
<td>-0.14</td>
<td>(-0.17, -0.11)</td>
</tr>
<tr>
<td>Path D: Slope WB &lt;-- Intercept WB</td>
<td>-0.10</td>
<td>(-0.15, -0.05)</td>
<td>-0.08</td>
<td>(-0.12, -0.03)</td>
</tr>
<tr>
<td>Path E: Slope WB &lt;-- Intercept SMI</td>
<td>0.10</td>
<td>(0.004, 0.19)</td>
<td>0.03</td>
<td>(-0.03, 0.10)</td>
</tr>
<tr>
<td>Path F: Slope SMI &lt;-- Intercept WB</td>
<td>0.01</td>
<td>(-0.01, 0.02)</td>
<td>-0.001</td>
<td>(-0.01, 0.01)</td>
</tr>
<tr>
<td>Model Fit</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Loglikelihood</td>
<td>-31170.95</td>
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<td>-31064.01</td>
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<td>AIC</td>
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<td>BIC</td>
<td>62799.19</td>
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<td>62586.86</td>
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</table>

Abbreviation: AIC, Akaike Information Criterion; BIC, Bayesian Information Criterion; CI, Confidence Interval; PE, Raw parameter estimate; SMI, Social Media Interaction; WB, Well-being; -->, regression; <--., correlation

*Coefficients are correlations
Growth Curve Example 2: SEM Specification (IV) - Boys

- SNS Use Age 10
- SNS Use Age 11
- SNS Use Age 12
- SNS Use Age 13
- SNS Use Age 14
- SNS Use Age 15

- SDQ Age 10
- SDQ Age 11
- SDQ Age 12
- SDQ Age 13
- SDQ Age 14
- SDQ Age 15

- SDQ Intercept
- SDQ Slope

- SNS Use Intercept
- SNS Use Slope

- Asian
- Household Income
- Black African/Caribbean

- Intercept
- Slope

- SDQ

- -0.11 (0.04)
- -0.48 (0.17)
- -1.38 (0.64)
- 0.73 (0.32)
- -0.08 (0.03)

- 0.06 (0.03)
- 0.08 (0.17)
- 1.56 (0.42)
- 0.73 (0.32)

- 0.48 (0.17)
- 1.56 (0.42)
- -0.11 (0.04)
- 0.73 (0.32)

- -0.11 (0.04)
- -0.48 (0.17)
- -1.38 (0.64)
- 0.73 (0.32)

- Household Income

- Black African/Caribbean

- Asian

- SDQ

- SNS Use

- Intercept

- Slope
Growth Curve Example 2: SEM Specification (IV) - Girls

- **SNS Use**
  - Age 10
  - Age 11
  - Age 12
  - Age 13
  - Age 14
  - Age 15

- **SDQ**
  - Age 10
  - Age 11
  - Age 12
  - Age 13
  - Age 14
  - Age 15

**Coefficients**:
- SNS Use Intercept: 0.08 (0.02)
- SNS Use Slope: 0.08 (0.03)
- SDQ Intercept: 0.09 (0.03)
- SDQ Slope: 0.09 (0.03)

**Demographic Factors**:
- Asian: 0.10 (0.03)
- African/Caribbean: 1.72 (0.48)
- Household Income: 0.09 (0.03)
- Mixed: 0.28 (0.14)
- Other: 0.36 (0.12)
- Black: -0.72 (0.29)
- African/Caribbean: -0.14 (0.07)
- Household Income: -0.28 (0.14)
- Mixed: -0.72 (0.29)
Any questions?
Resources

- https://stats.oarc.ucla.edu/
- https://www.statmodel.com/
- https://www.bristol.ac.uk/cmm/research/lemma/1/
Opportunities

• COORDINATE
  • Transnational Visits
    • [https://www.coordinate-network.eu/transnational-visits](https://www.coordinate-network.eu/transnational-visits)
    • Next call: August 29, 2022
    • Visits possible to 9 different sites including Essex
  • Future Summer Schools
    • Leibniz Institute for Educational Trajectories, Bamberg
    • Catalan Youth Observatory, Barcelona

• Understanding Society
  • Fellowships
    • [https://www.understandingsociety.ac.uk/research/fellowships](https://www.understandingsociety.ac.uk/research/fellowships)
    • Deadline: June 30, 2022
  • International Conference
    • Summer 2023
Lunch