Longitudinal Data Analysis with the Multilevel Model for Change

Overview

The longitudinal dataset
- Structure
- Example we will use

The multilevel model
- Formula
- description

Example in R
- Model
- Plot

The Longitudinal dataset

Person-Period structure is considered optimal

- Can have time varying and time invariant variables

Important features to model change

- 3 or more waves
- An outcome whose values change systematically over time (time varying)
- Sensible metric for clocking time

	id	age	coa	male	age_14	alcuse	peer	cpeer	ccoa
1	1	14	1	0	0	1.732051	1.2649111	0.2469111	0.549
2	1	15	1	0	1	2.000000	1.2649111	0.2469111	0.549
3	1	16	1	0	2	2.000000	1.2649111	0.2469111	0.549
4	2	14	1	1	0	0.000000	0.8944272	-0.1235728	0.549
5	2	15	1	1	1	0.000000	0.8944272	-0.1235728	0.549
6	2	16	1	1	2	1.000000	0.8944272	-0.1235728	0.549
7	3	14	1	1	0	1.000000	0.8944272	-0.1235728	0.549
8	3	15	1	1	1	2.000000	0.8944272	-0.1235728	0.549
9	3	16	1	1	2	3.316625	0.8944272	-0.1235728	0.549
10	4	14	1	1	0	0.000000	1.7888544	0.7708544	0.549
11	4	15	1	1	1	2.000000	1.7888544	0.7708544	0.549
12	4	16	1	1	2	1.732051	1.7888544	0.7708544	0.549
13	5	14	1	0	0	0.000000	0.8944272	-0.1235728	0.549
14	5	15	1	0	1	0.000000	0.8944272	-0.1235728	0.549
15	5	16	1	0	2	0.000000	0.8944272	-0.1235728	0.549
16	6	14	1	1	0	3.000000	1.5491934	0.5311934	0.549
17	6	15	1	1	1	3.000000	1.5491934	0.5311934	0.549
18	6	16	1	1	2	3.162278	1.5491934	0.5311934	0.549
19	7	14	1	0	0	1.732051	1.5491934	0.5311934	0.549
20	7	15	1	0	1	2.449490	1.5491934	0.5311934	0.549
21	7	16	1	0	2	1.000000	1.5491934	0.5311934	0.549
22	8	14	1	1	0	0.000000	0.0000000	-1.0180000	0.549
23	8	15	1	1	1	0.000000	0.0000000	-1.0180000	0.549
24	8	16	1	1	2	0.000000	0.0000000	-1.0180000	0.549

The Longitudinal dataset

Changes in adolescent alcohol use

- 3 waves of 82 adolescents each year beginning at age 14
- COA = child of alcoholic parent
- PEER = measure of alcohol use among the adolescent's peers
- ALCUSE = measure of an adolescent's alcohol use
- Age_14 is the time variable used (age – 14)

How does COA and PEER affect ALCUSE over time?

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The Multilevel model for change

Level 1 model – individual growth

- $Y_{ij} = \beta_{0i} + \beta_{1i} TIME_{ij} + \varepsilon_{ij}$

Level 2 sub model – fixed effects/interindividual change

- $\beta_{0i} = \gamma_{00} + \gamma_{01} COA_i + \gamma_{02} PEER_i + \zeta_{0i}$
- $\beta_{1i} = \gamma_{10} + \gamma_{12} PEER_i + \zeta_{1i}$

The Multilevel model – in words

Level 1 model

- intercept and slope for individual *i* in population

Level 2 model

- Fixed effects (gamma)
  - γ_{00} is population average intercept for non-COA and non-PEER
  - γ_{01} and γ_{02} are the differences in population average intercepts for COA and PEER
  - γ_{10} and γ_{12} are the population average slope and difference in PEER slope

Benefit of the multilevel approach

- Provides an efficient way to show how different predictors affect individual intercept and slope

Modeling in R

library(nlme)

- Linear and nonlinear mixed effects models

lme() function

- lme(alcuse ~ coa+peer*age_14 , data=alcohol1, random= ~ age_14 | id, method="ML")

- lme(model with fixed effects, data, random effects | grouping, method is maximum likelihood)

nlme()

- Nonlinear – maybe in another presentation…

Modeling in R

Recommended way to visualize change is to plot prototypical values for predictors

- COA = 0 or 1
- Prototypical values for PEER can be generated by taking ± .5 standard deviation of sample mean
  - .655 (low) and 1.381 (high)
- Plot fixed effects with these values

```
Linear mixed-effects model fit by maximum likelihood
  Data: alcohol1
       AIC      BIC    logLik
  606.7033 638.2513 -294.3516

Random effects:
 Formula: ~age_14 | id
 Structure: General positive-definite, Log-Cholesky parametrization
            StdDev   Corr
(Intercept) 0.490839 (Intr)
age_14      0.373038 -0.034
Residual    0.580769

Fixed effects:  alcuse ~ coa + peer * age_14
                 Value  Std.Error  DF   t-value p-value
(Intercept) -0.3138215 0.14762324 162 -2.125827  0.0350
coa          0.5711970 0.14773614  79  3.866332  0.0002
peer         0.6951827 0.11240370  79  6.184696  0.0000
age_14       0.4246867 0.10667944 162  3.980961  0.0001
peer:age_14 -0.1513771 0.08538522 162 -1.772873  0.0781
 Correlation:
            (Intr) coa    peer   age_14
coa         -0.338
peer        -0.709 -0.146
age_14      -0.410  0.000  0.351
peer:age_14  0.334  0.000 -0.431 -0.814

Standardized Within-Group Residuals:
        Min          Q1         Med          Q3         Max
-2.59554447 -0.40414054 -0.08351858  0.45549533  2.29975194

Number of Observations: 246
Number of Groups: 82
```

Modeling in R

How does COA and PEER affect ALCUSE over time?

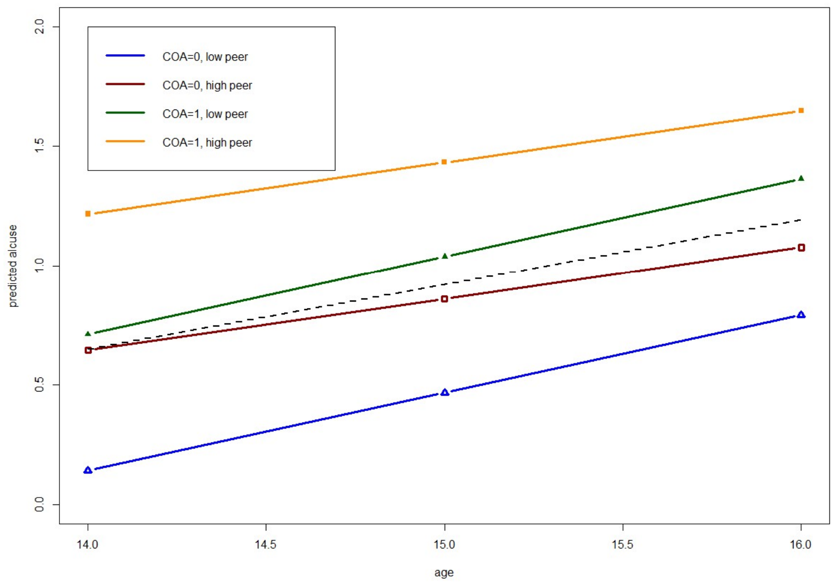
PEER	COA	Intercept β_{0i}	Slope β_{1i}
Low	No	.142	.326
Low	Yes	.713	.326
High	No	.646	.216
High	Yes	1.217	.216

$$-.314 + .571(1) + .695(1.381)$$

$$\beta_{0i} = \gamma_{00} + \gamma_{01}COA_i + \gamma_{02}PEER_i$$

$$.425 - .151(1.381)$$

$$\beta_{1i} = \gamma_{10} + \gamma_{12}PEER_i$$



References

Applied Longitudinal Data Analysis by Singer and Willett

Applied Longitudinal Data Analysis, Chapter 4 | R Textbook Examples (ucla.edu)

nlme: Linear and Nonlinear Mixed Effects Models (r-project.org)