Why Multilevel Models Are Good Models For Longitudinal Data

Multilevel Models Offer An Incredibly Flexible Treatment of Time and Time Varying Processes and Covariates

Andy Grogan-Kaylor

2025-10-23

Table of contents

1 Visually

2 Data Structures

Multilevel models for longitudinal data prefer data in long format.

Table 1: Data in WIDE format

id	x1	x2	x3	y1	y2	y3
1						
2						
3						

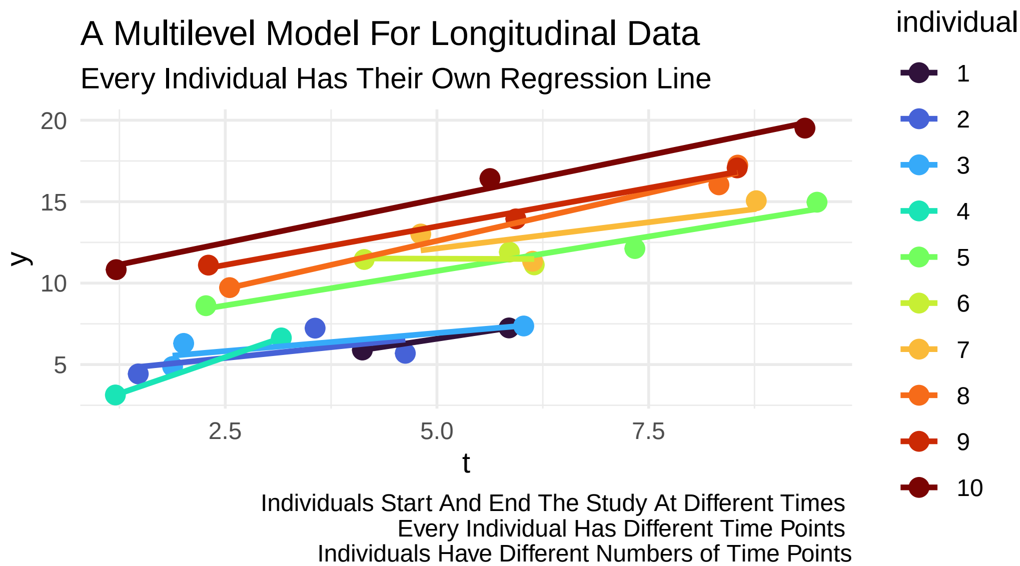

Figure 1: A Multilevel Model For Longitudinal Data

Table 2: Data in LONG format

id	t	x	y
1	1		
1	2		
1	3		
2	1		
2	2		
2	3		
3	1		
3	2		
3	3		

3 Equation

$$y_{it} = \beta_0 + \beta_1 t_{it} + \beta_2 x_{it} + u_{0i} + e_{it} \tag{1}$$

Person-Observations

Every row is a *person-observation* (person i observed at time t). Every person has *multiple rows*.

4 Advantages of the Multilevel Model for Longitudinal Data [1]

1. Using the algebra in Equation 1, these models can easily accommodate both time varying and time invariant coefficients (Hox, 2010; Hox et al., 2018; Rabe-Hesketh & Skrondal, 2022; Raudenbush & Bryk, 2002; Singer & Willett, 2003).
2. There is no multicollinearity issue with multiple β coefficients for multiple waves of data. By inspection of Equation 1, we see that there is only a single β coefficient for each variable, $\therefore$ no multicollinearity problem.
3. *Unbalanced data is less of a problem*, the data structure and estimation are robust to these possibilities (Raudenbush, 1995; Raudenbush & Bryk, 2002; Singer & Willett, 2003).
4. *Missing data is less of a problem* (assuming *MCAR*). When a person observation is missing, that person simply has fewer rows of data (Hox, 2010; Luke, 2004; Rabe-Hesketh & Skrondal, 2022; Raudenbush, 1995; Raudenbush & Bryk, 2002). But all rows of data are "matched" to the same person by i.
5. We have an *explicit function of time* $\beta_1 t$, and could treat time more flexibly, by creating a polynomial function of time e.g. by adding $\beta_2 t^2$, etc. (Raudenbush & Bryk, 2002; Singer & Willett, 2003). (We could even substitute $\beta \ln(t)$.)
6. Again, by inspection of Equation 1, we see that *multiple or many time-points are not a problem*. We would use the same algebra for 2 time points or for 10,000 time points. (Helpful when we start to think about intensive longitudinal data *e.g.* George Holden's *recording study*).
7. We are *measuring exactly the time at which events take place* for each individual (Luke, 2004; Singer & Willett, 2003). Not simply saying *Wave 1*, *Wave 2*, *Wave 3*, etc…
8. Unequally spaced time points are not a problem (Raudenbush, 1995). Every individual could have a *completely different set of time points* and even a *completely different number of time points* (Hox, 2010; Hox et al., 2018; Luke, 2004; Singer & Willett, 2003).

> Caution
>
> We do need to think carefully about what is the appropriate variable for time. Is it the variable we used to reshape the data–often `wave`–or some other more appropriate metric, like `age` or `time in study` (Singer & Willett, 2003)?

References

Hox, J. (2010). *Multilevel analysis: Techniques and applications* (2nd ed.). Routledge.

Hox, J., Moerbeek, M., & van de Schoot, R. (2018). *Multilevel analysis: Techniques and applications* (Third edition.). Routledge, Taylor & Francis Group,.

Luke, D. (2004). *Multilevel modeling*. SAGE Publications, Inc. https://doi.org/10.4135/9781412985147

Rabe-Hesketh, S., & Skrondal, A. (2022). Multilevel and longitudinal modeling using stata. In *Stata Press* (4th ed.). Stata Press.

Raudenbush, S. W. (1995). Hierarchical linear models to study the effects of social context on development. In J. M. Gottman (Ed.), *The analysis of change* (pp. 165–199). Lawrence Erlbaum Associates.

[1] Many, if not most, of the advantages listed below will also apply to any approach using long data.

Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models: Applications and data analysis methods*. Sage Publications.

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