# Introduction to Applied Bayesian Modeling

Day 487

ICPSR

2008

# Multilevel Models

- Common to Social sciences given structure of our data
  - Repeated measures at different times
  - Different 'units' at same times
  - Different 'units' at different times
    - All of these have implications for modeling strategies that conventional techniques can't handle.

# MLM

- LOTS and LOTS of lingo and jargon…I
  - Multilevel
  - Hierarchical
  - Random
  - Fixed
  - Mixed
  - Latent class
  - Latent growth
  UGH!!

# What do these all mean?

- Well, that's up for debate…
- HLM and MLM are the same thing
- Hierarchy or mulit-leveledness can be:

  - Substantive
  - Methodological
  - Both

# Effects…

- We talk about:
  - Fixed effects
    - Intercepts
    - Coefficients
    - Both
  - Random effects
    - Intercepts
    - Coefficients
    - both

# So, what are fixed and random

- It depends on your perspective…
  - In the TSCS world, the distinction is more clear:
    - Fixed effects are a within-unit estimator and only use variance within unit across time to get estimates of effects.
    - Between (yet more jargon) effects are, well, estimators based on variance between units, contemporaneously. (i.e. France and Germany in 1992)
    - Random effects are a weighted average of the two types of variance. So, the more within-unit variance, the more RE looks like FE. The more between unit variance, the more RE looks like BE.
      - Requires more stringent assumptions than FE
      - However, more efficient—fewer things estimated

# Other meanings…
## from our ol' Buddy Gelman

- Fixed effects are constant across individuals and random effects vary across individuals.  (Kreft and De Leeuw)

- Effects are fixed is they are interesting in themselves or random if there is interests in the underlying population.  (Searle, Casella, and McCulloch)

# More other meanings…

- "When a sample exhausts the population, the corresponding variable is *fixed*; when the sample is a small part of the population the corresponding variable is *random*." (Green and Tukey).

- "If and effect is assumed to be a realized value of a random variable, it is called a random effect" (LaMotte).

# Even more meanings…

- Fixed effects are estimated using least squares (or, more generally, MLE) and random effects are estimated with shrinkage ("linear unbiased prediction"). This is the standard definition is the multilevel modeling literature (Snijders and Bosker). This implies that:

  – FE are conditional on a group-level variance = infinity.
  – RE are conditional on variance estimated from data.

# Hmm…

- These definitions all have some similarities, but:
  - effects can change conditional on goals of inference.
  - Effects can change based on size of samples
- In sum, effects can be fixed or random depending on which definition you use.
- HOORAY!!!

# Much ado about nothing that really matters to us…

- Because we are Bayesians!!!

# Everything is random.

- Think about it…
  - Everything we estimate in a Bayesian model is a 'random' effect

- What is a posterior distribution...
  - It's a probability distribution.
  - We take random draws from the posterior and summarize them.

# Everything is random

- After all, one of the most convincing arguments for the Bayesian paradigm is:

  - The things we care about are not accurately represented as point estimates, right?
  - The DATA are fixed, the parameters are…

  - Wait for it…

# Everything's random…

# RANDOM!!

# So, why multilevel models?

- We can account for individual and group-level variation in group-level coefficients.

- We can model variation in individual level regression coefficients

- We can estimate effects within groups even if sample size is a problem, for example

- We can do these for intercepts as well

# Why MLM

- It does introduce model complexity.
  - But all models are wrong, some are helpful
  - More realistic models are usually more helpful
- Makes a difference when there is real group-level variation.
  - With little or no group-level variation, MLM reduces to classical regression
  - With LOTS of group-level variation, MLM reduces to classcal regression with group indicators

# How do we do this?

- Well, we already have (in some ways).

- WinBUGS models are all multi-level models.

  - A methodological hierarchy, not necessarily substantive.

  - Jumping to substantive hierarchy is EASY.

    - We basically do exactly what we've been doing, but simply index things somewhat differently.