Methodological Issues

Effect modification: limits of conventional approach

- Low statistical power
- Limited functional forms
- Difficulty interpreting 3+ way interactions
- Misspecified “main” effects
- “Statistical interaction formulations are inadequate to capture the ecology of human development”* page 924

* Source: Evans GW. Dev Psychol 2003, 39:924-33.

Alternatives to interaction terms

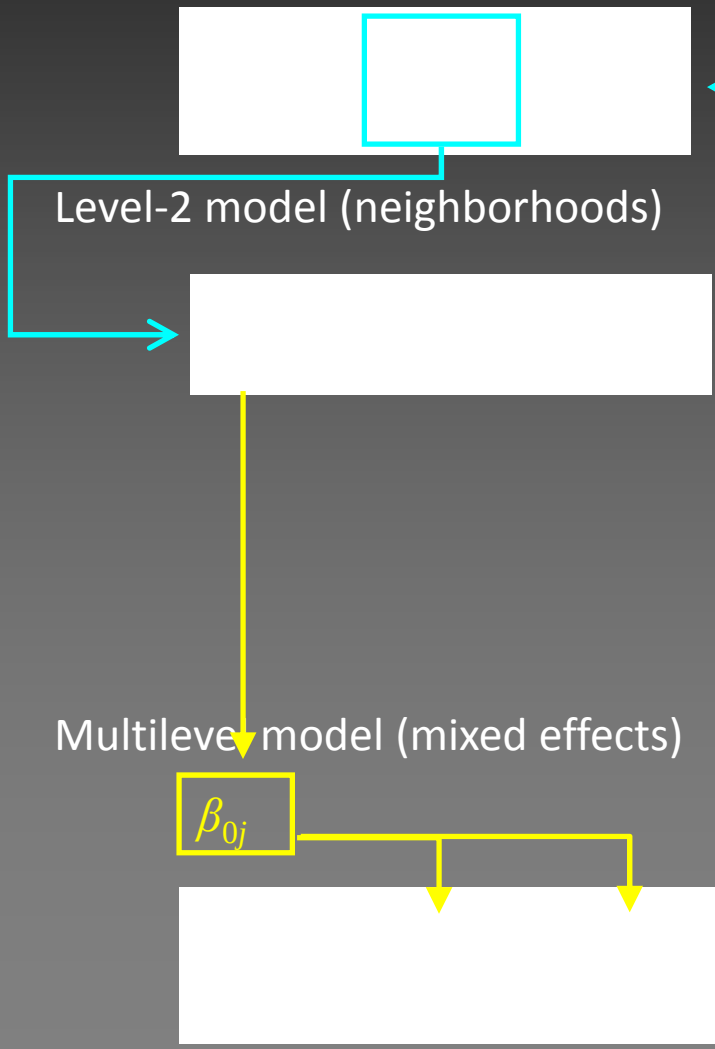
- Cumulative risk model (Rutter 1983)
  - Sum discrete risk using standard threshold cutoffs
- Decision tree analysis (Breiman, 2001)
  - Assumes no explicit causal model, fully capture complex interactions
- Systems dynamics models (Galea, 2009)
  - Feed back, non-linearities
- Hierarchical (aka multi-level) models (Raudenbush & Bryk, 2002)
  - Nested data; cross-level interactions; random slopes to model risk heterogeneity
  - Model the **social ecology of risk**

Example: Multilevel (hierarchical models) for differential vulnerability

- Hypothesis: The effect of air pollution (PM_{10}) is exacerbated for residents of high crime neighborhoods due to prolonged exposure to psychosocial hazards
- Clustered data
  - 1000 individuals
  - 50 neighborhoods/communities
- Individually monitored PM_{10} exposure
  - High (e.g., 90^{th} percentile) vs. not-high

Model 1:
Does risk vary by social ecology?

Level-1 model (individual-level)



Y_{ij} is the systolic blood pressure of the *i*th person in the *j*th neighborhood where:

r_{ij} = random error associated with *i*th person in *j*th neighborhood ~$N(0,\sigma^2)$

β_{0j} is the neighborhood-specific intercept where:

γ_{00} = the overall mean SBP across all NBs.

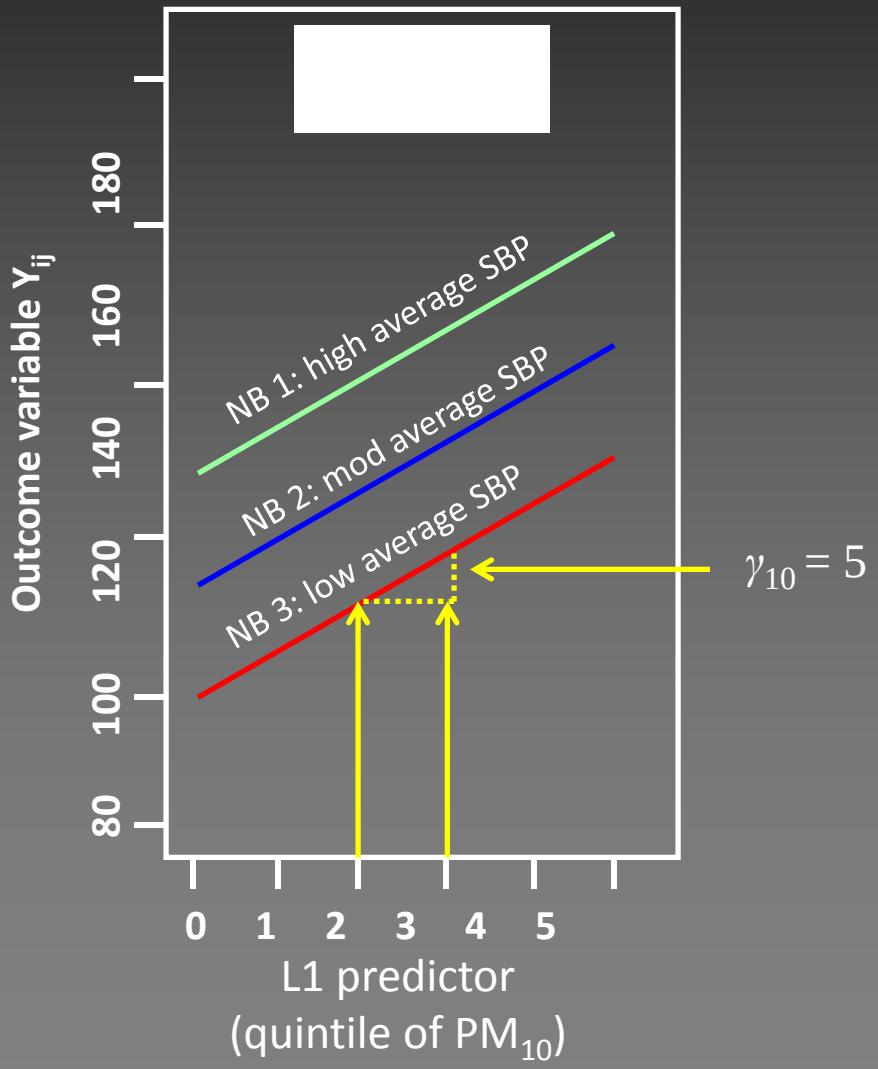
u_{0j} = a series of random deviations from the mean ~$N(0,\tau_{00})$

where:

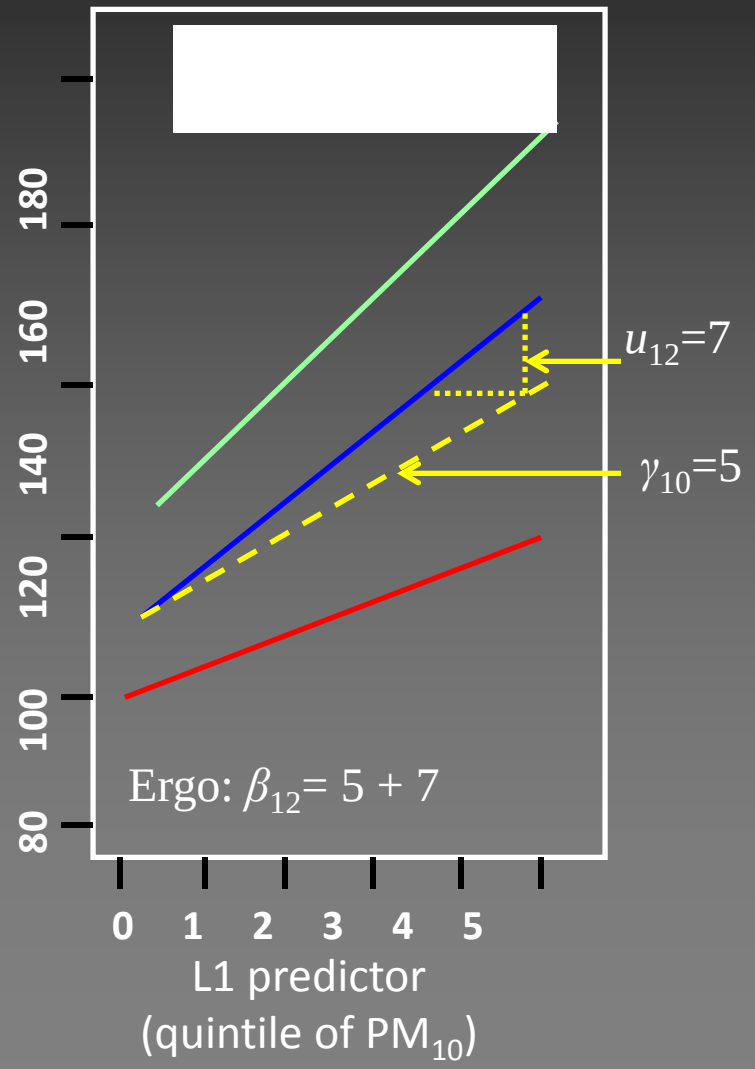
$\text{cov}(r_{ij},u_{0j}) = 0$

Visualizing random intercepts and slopes

Random intercepts:

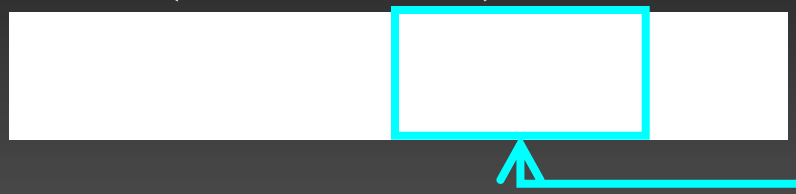


Random intercepts and slopes:



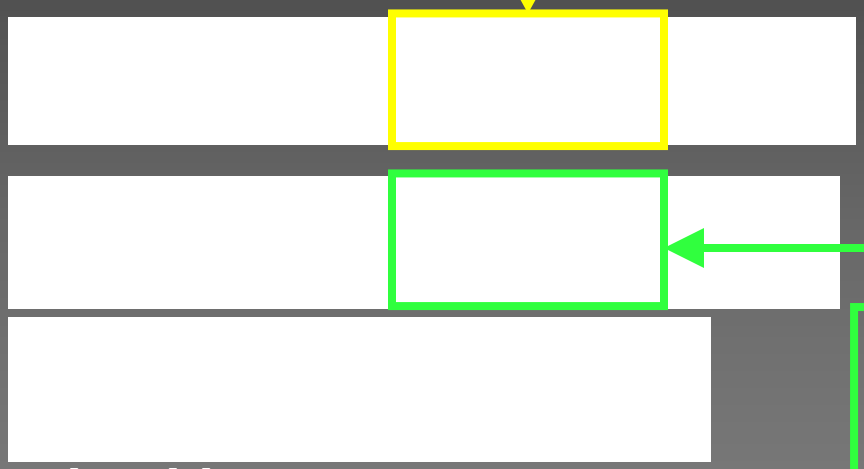
Model 2: Modeling cross-level interactions

Level-1 model (individual-level)



PM_{10ij} is a covariate coded 1 if *i*th person in *j*th neighborhood is exposed to high levels of PM10, 0 if not

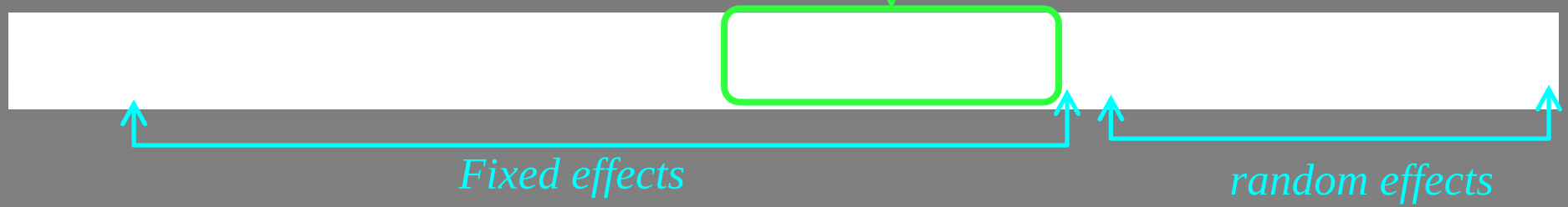
Level-2 model (neighborhood level)



γ_{01} is the mean difference in SBP associated with a 1 standard deviation increase in crime rate in those not exposed to high PM_{10}

γ_{11} is extent to which the marginal change in SBP for those living in a high crime NB among exposed vs. non-exposed (implicit cross-level interaction)

Multilevel model:

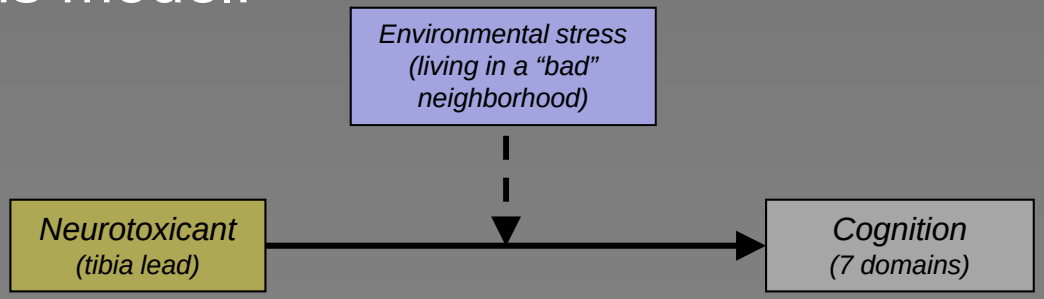


Fixed effects

random effects

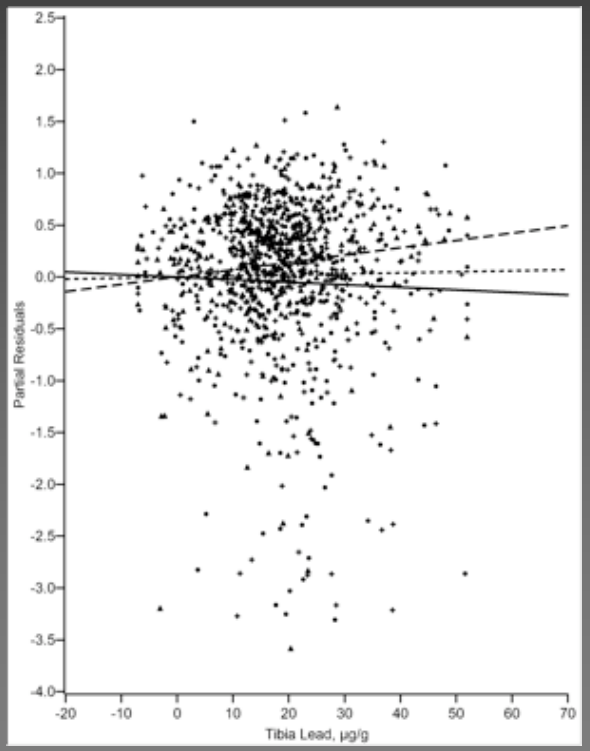
Real world example: Environmental stress, lead and cognition

- Animal models show environmental stress worsens lead effect on brain/cognition
- The Baltimore Memory study
  1. 1140 community-dwelling adults aged 50-70 in 65 contiguous Baltimore neighborhoods
  2. Tibia lead measured using XRF spectroscopy
  3. Measure “environmental stress” (toxicology term) with a scale of neighborhood psychosocial hazards (social epidemiology term)
- Test this model:

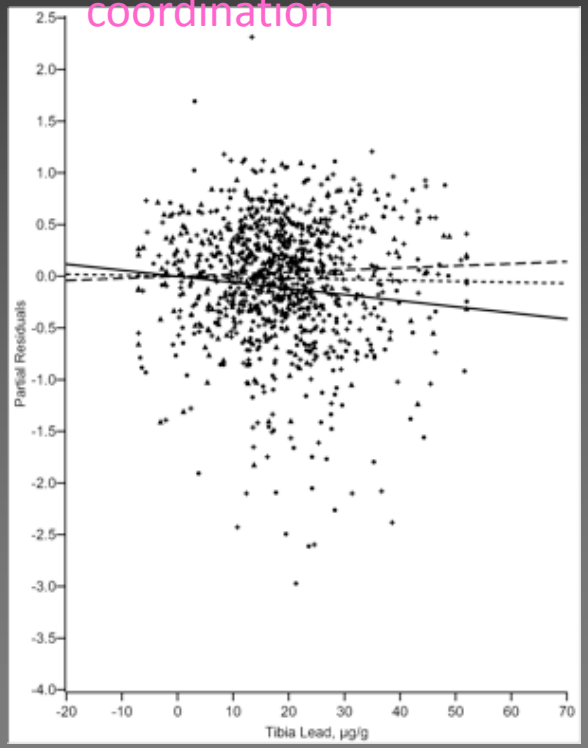


Neighborhood psychosocial hazards exacerbate association of tibia lead on cognition

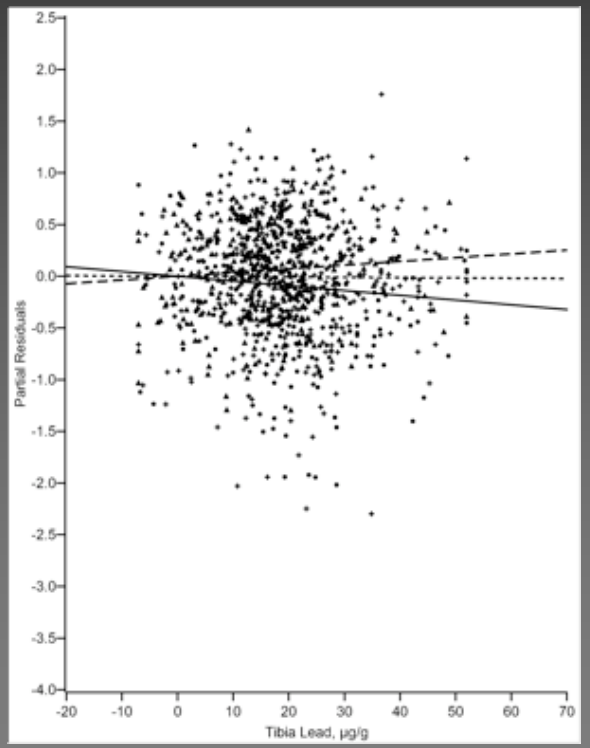
Processing speed



Eye-hand coordination



Executive ability



Legend:

Highest tertile NPH score = ——————

Middle tertile NPH score = ...

Lowest tertile NPH score = – – – – -

Source: Glass TA, et al. AJE 2009, 169:683-92.

Living beyond our means: Why not Measure what we Want?

- Traditional Regression analysis models the mean response in the population
- The risk in the population may be high for a small subset
- Quantile regression:
  - directly estimate the effect on 95th percentile of risk, rather than on the mean risk
  - Modeling multiple quantiles estimates the change in the distribution