NEBRASKA ACADEMY FOR METHODOLOGY, ANALYTICS & PSYCHOMETRICS

Methodology Applications Series

2020-2021

University of Nebraska Lincoln

NEBRASKA ACADEMY FOR
METHODOLOGY, ANALYTICS & PSYCHOMETRICS

Modeling Context:
To Kansas and Beyond

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Context

- Bronfenbrenner and Morris (1983)
  – "Any event or condition outside the organism that is presumed to influence, or be influenced by, the person's development" (pp. 359)
    - this definition is broad, and necessarily so
- "Context" is often used synonymously with "environment"
  – features outside of the growing, changing person/unit that potentially affect or are affected by the individual [person/unit] and his/her[/its] growth
- Studying individual change within an environment that itself may be changing adds additional complexity and challenges (as well as opportunity) to developmental research.

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Bronfenbrenner's Ecological Model

- *Microsystem*
  - the individual's immediate social **settings** that directly affect the individual's life
    - ***family, peer group, classroom***
- *Mesosystem*
  - connects the various microsystems together
  - Immediate linkages between settings
    - ***parents' relations with school personnel***
- *Exosystem*
  - made up of structures that affect the functioning of micro- and meso- systems; macro-linkages between settings
    - ***neighborhood, community***
- *Macrosystem*
  - overarching network of cultural, political, and economic patterns that influence the lower levels
    - ***the system by which the elderly are cared for within a culture or nation***
- *Chronosystem*
  - the way in which these patterns change across time
  - Changes within the person & within the setting – and the dynamic interaction between them
    - ***historic period (e.g., the Great Depression, World War II, 9/11, NCLB)***

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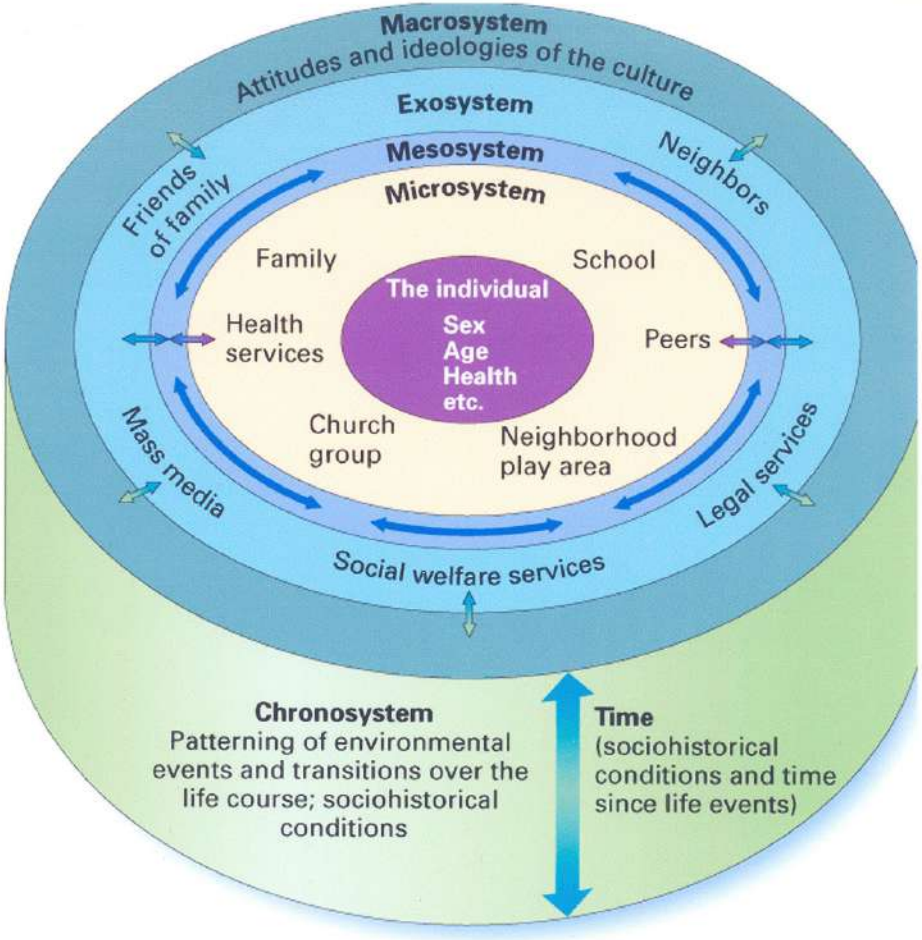
Ecological/Contextual Model



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Need to Expand Context Models

- Bronfenbrenner's model
  - Important framework
  - Handles social ecology
- What about non-social ecology
  - Genes
  - Environmental toxins
  - Prenatal and perinatal factors

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Levels of Behavioral Influence

- Beneath the Skin
  - Genetic
  - Molecular
  - Cellular
  - organic
- Above the Skin
  - Family
  - institution (schools, work sites, health care)
  - Community or municipality
  - State
  - National
  - global

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Pediatric Obesity as a Multilevel Epidemic

- Obesity is both a social and a biological problem
  - Population level:
    - Biological susceptibilities & socio-environmental changes have shaped lifestyle & society
  - Individual level:
    - Genetic & metabolic programming predisposes weight gain and resistance to weight loss
  - Result:
    - Eating and exercise may be beyond rational control for some.
- Systems approach for sustainable intervention:
  - Individual dietary, physical activity, & sedentary behaviors don't occur in isolation
  - Requires simultaneous consideration of biological & socio-environmental drivers

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Pediatric Obesity as a Multilevel Epidemic

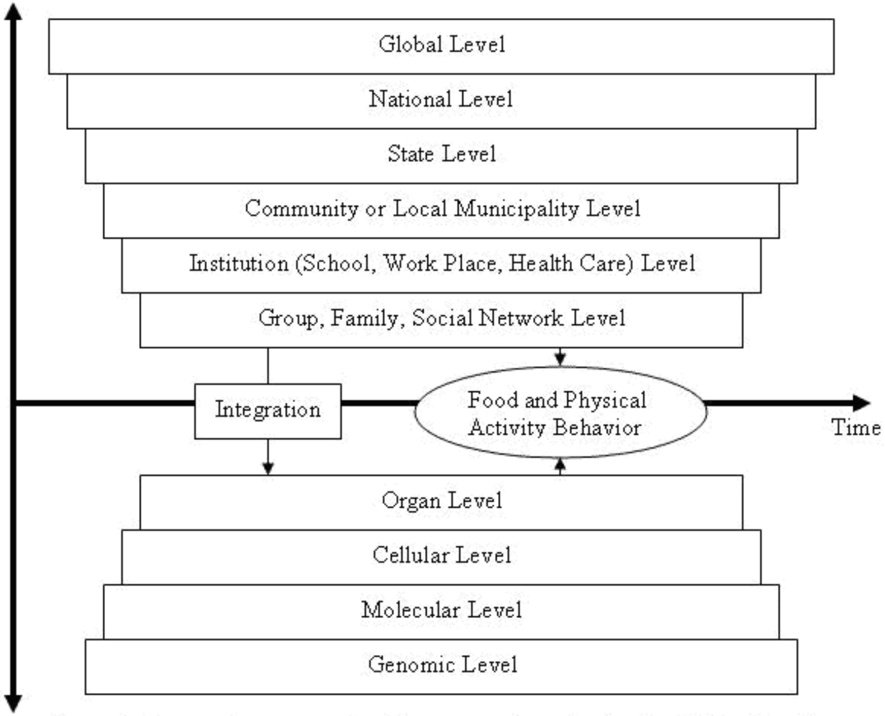

Figure 1.: The x-axis represents time, from conception to death at the individual level or trajectory of social change at the population level. The y-axis represents the hierarchy of factors below and above the skin that can influence obesity-related behaviors, from genetics all the way to global geopolitical and economic forces.

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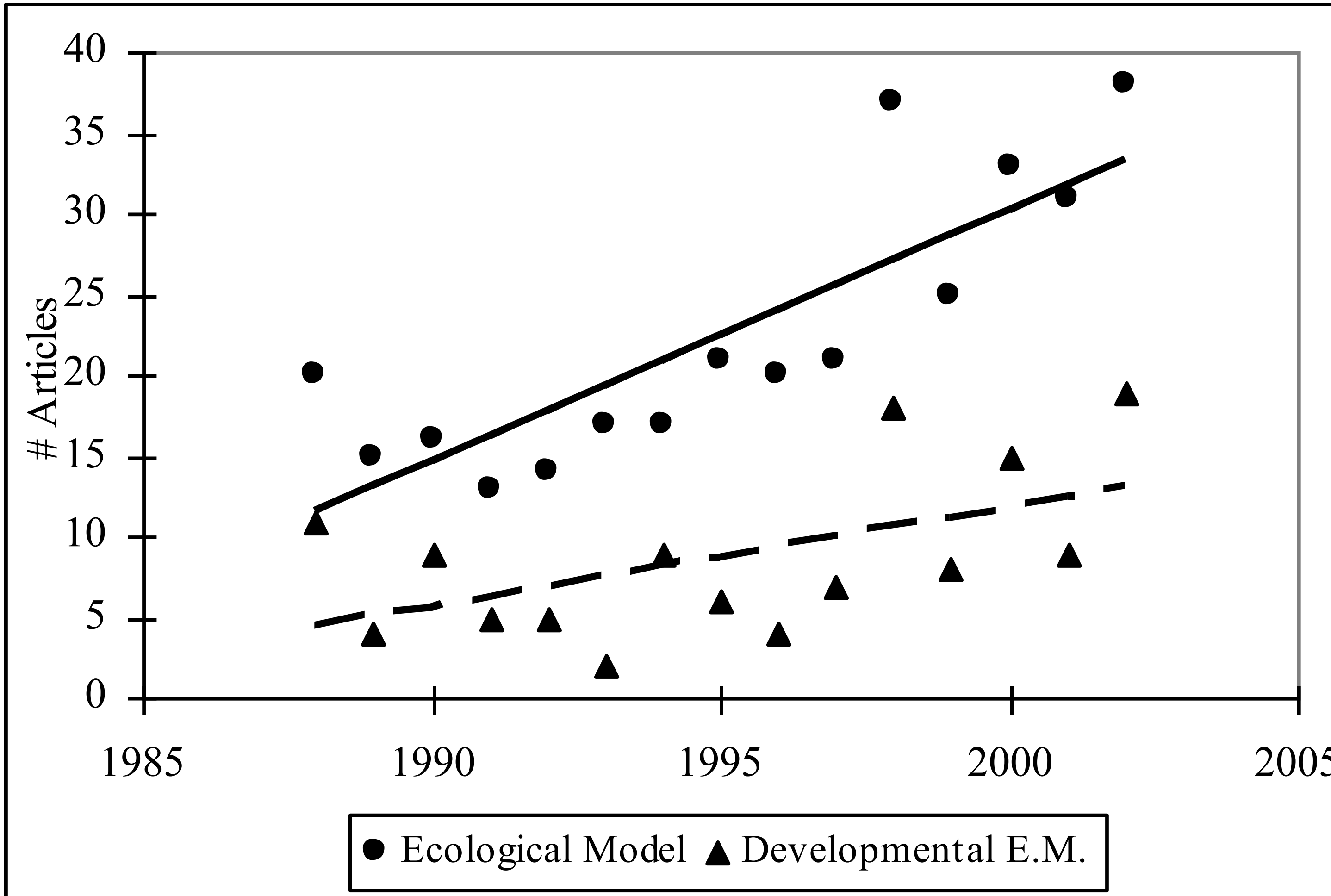
Use of the Ecological Model



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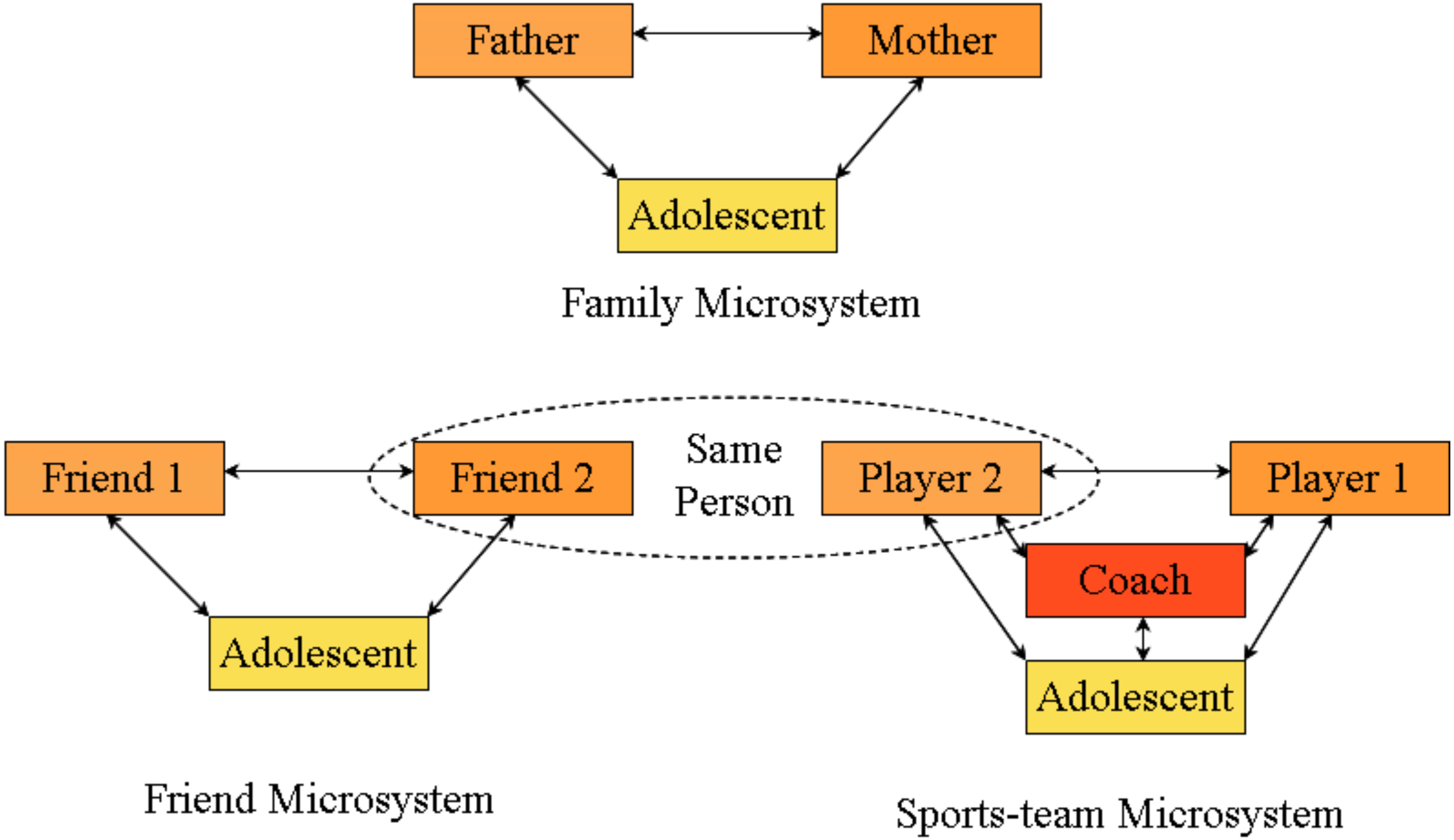
The Microsystems



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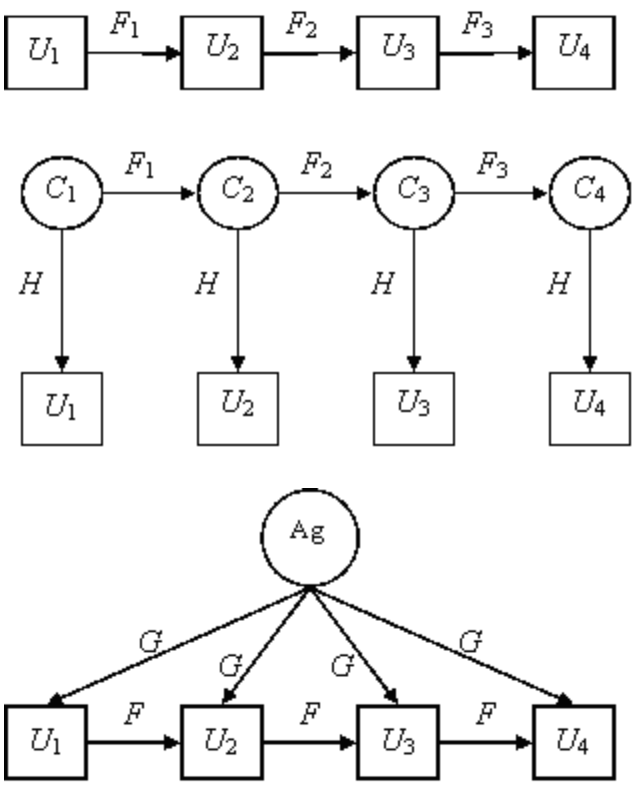
Transitions of School Bullying Status During High School: Changing Status/State as a Chronosystemic Microsystem

- From:
  - Penn, J., Gaskill, T., Bovaird, J.A., Siebecker, A., Givens, J., & Swearer, S.M. (2007, August). *Changes in Bullying Over Time: An Application of Markov Models.* Paper presented at the American Psychological Association annual meeting. San Francisco, CA.



- U - observed bully (yes/no) status
- F – transition probabilities
- C - Latent bully (yes/no) status
- H – reliability of classification
- Ag – Aggression (covariate)
- G – predictive effect

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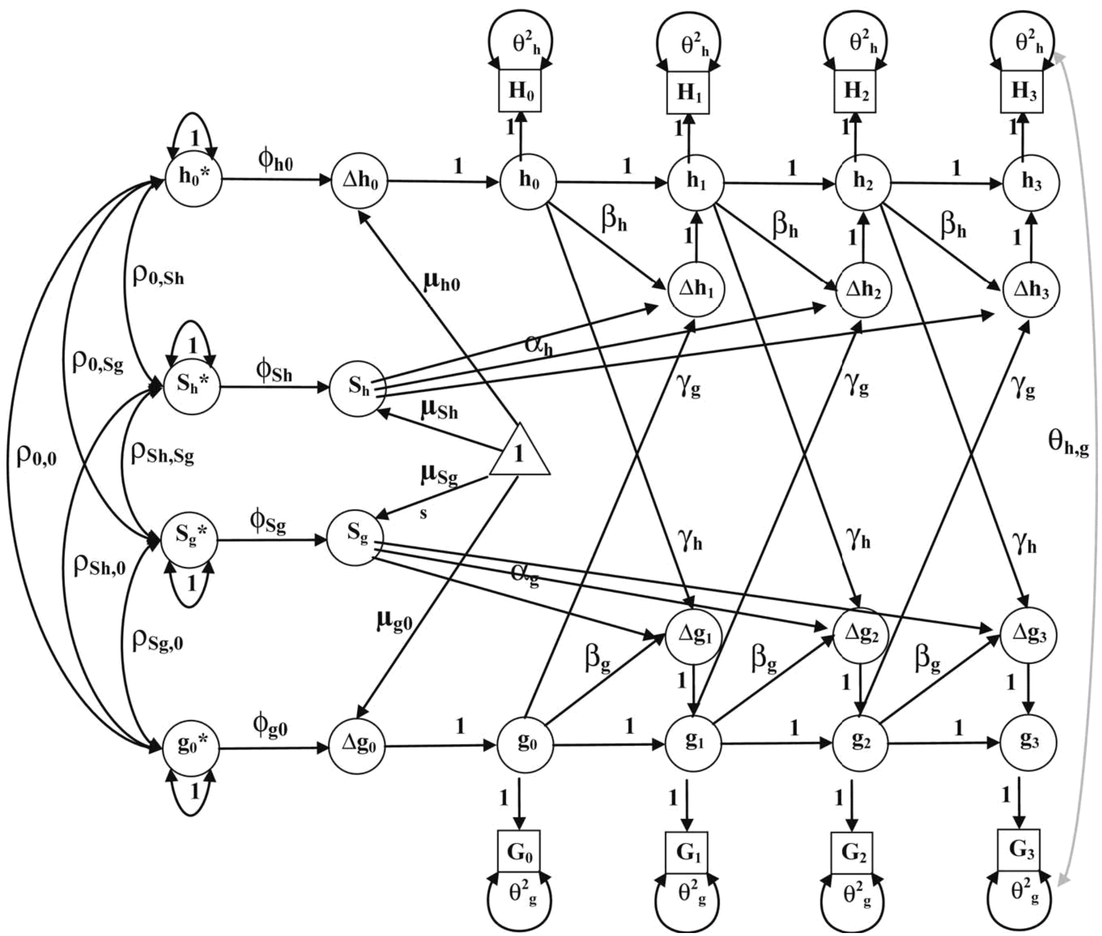
Dynamic Relations within a Microsystem



From: Little, T.D., Bovaird, J.A., & Slegers, D. (2006). Methods for the analysis of change. In Mroczek, D., & Little, T.D. (Eds.). *Handbook of Personality Development*. Mahwah, NJ: Erlbaum.

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Peer Interactions as a Microsystemic Dynamic System

Figure 1. Bivariate Model with cross-lagged effects (continuous outcome variables)

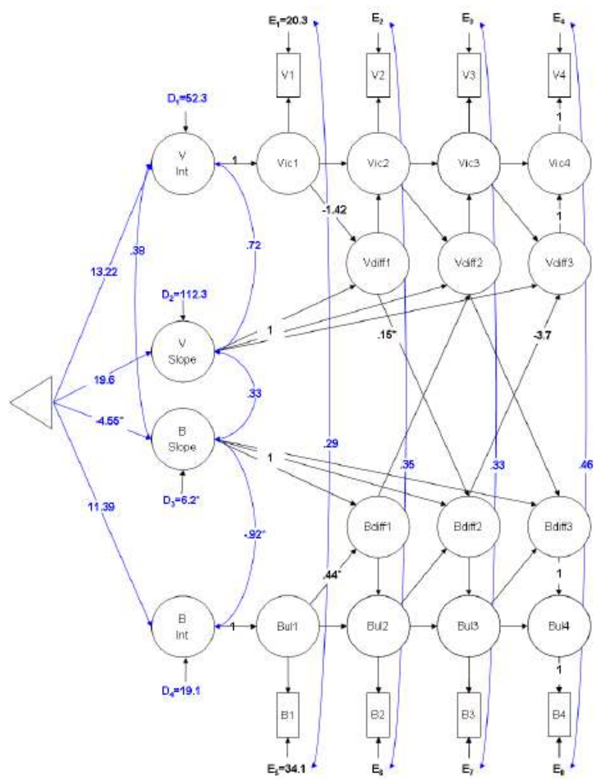
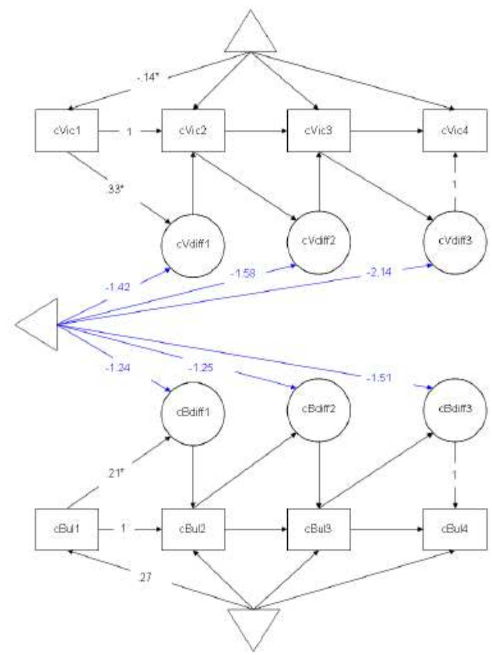


Figure 2. Bivariate model with categorical outcome variables



From: Römhild, A., Bovaird, J.A., Norman, R., Babl, J., & Swearer, S.M. (2007, August). *High School Bullying and Victimization: A Latent Difference Score Model*. Paper presented at the American Psychological Association annual meeting. San Francisco, CA.

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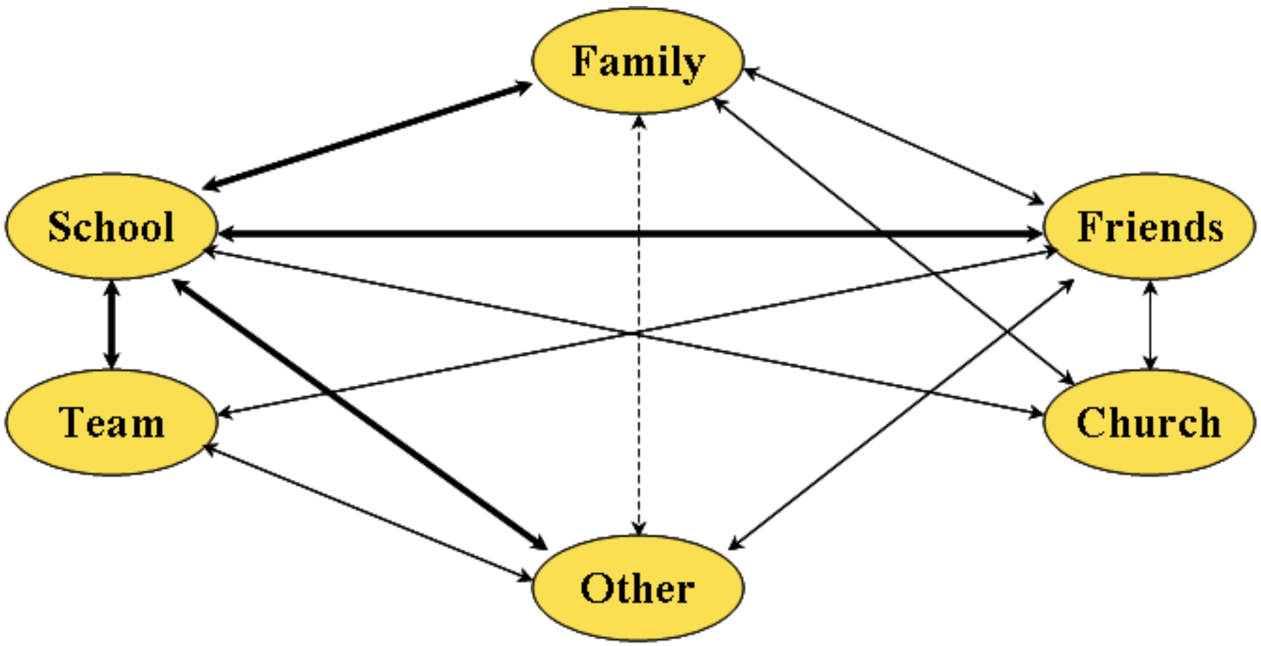
The Mesosystems



The various microsystems comprise the mesosystem. Interactions at the mesosystem are personal and direct (i.e., the adolescent is contained in each microsystem)

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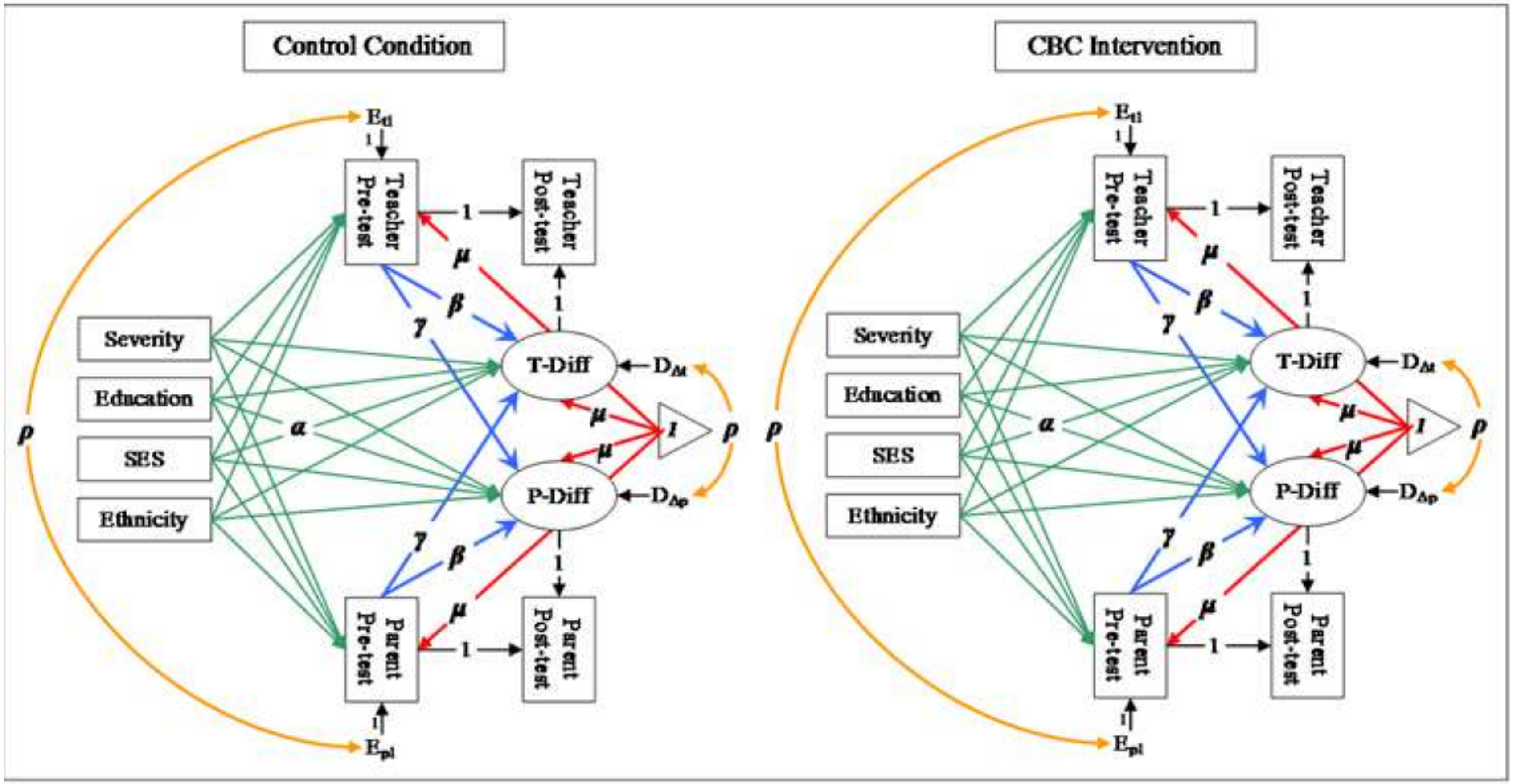
Parent-Teacher Relationship as a Mesosystem



From: Sheridan, S.M., Glover, T.A., & Bovaird, J.A., Garbacz, S.A., Swanger-Gagne, M.S., & Witte, A.L. (2007, June). *Influencing and Understanding Change in Parent-Teacher Relationships through Consultation-based Interventions.* Paper presented at the Institute for Education Science Research Conference. Washington, DC.

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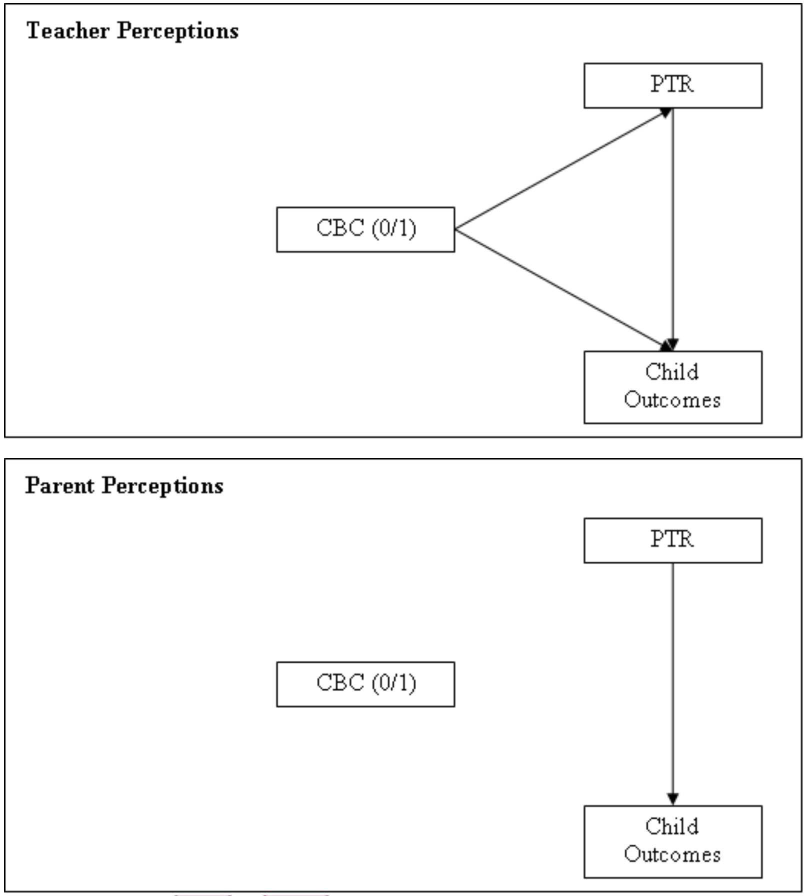
Differential Efficacy Throughout the Mesosystem

- Sheridan, S.M., Glover, T.A., Bovaird, J.A., Garbacz, S.A., & Kwon, K. (2009, June). *Conjoint Behavioral Consultation: Effects on Student Behaviors and Family-School Outcomes*. Paper presented at the Institute for Education Science Research Conference. Washington, DC.

- CBC = Conjoint Behavioral Consultation
- PTR – Parent-Teacher Relationship



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Modeling Context

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Broad Definition of Multilevel Modeling (MLM)

- ***A multilevel model simply contains variables measured at different levels of a sampling hierarchy***
  - clearly identified levels of aggregation
  - complex or stratified sampling procedures

- Do not confuse
  - hierarchically *nested* data
  - hierarchically *ordered* set of regression equations
- Two data analysis perspectives leading to the need for multilevel modeling procedures
  - complex sampling & random parameters
  - Both perspectives lead to the need to decompose the variability in outcome measures into between-group (contextual) and within-group (individual) sources
  - A general effect of a variable on an outcome within each contextual group
    - but that effect can vary randomly to a degree across groups

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MLM as a Contextual Model

- Models analyzing data obtained at **macro** and **micro** levels
  - Developed in the social sciences
  - Focus: context effects on individual behavior
  - Individual & context are distinct sources of variability
    - model as random influences

- Main model is the hierarchical linear model (HLM)
  - Extension of multiple regression to include nested random effects

- Key references:
  - Robinson (1950)
  - Davis, Spaeth, & Huson (1961)
  - Dogan & Rokkan (1969)
  - Burstein, Linn, & Capell (1978)

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MLM as a Contextual Model

- Each group/***context*** has the same explanatory variables (IVs) and the same outcome (DV)
  - Differ in regression coefficients
  - Models are linked together by the 2nd level

- Level 1 regression coefficients are regressed on the level 2 explanatory variables
  - Simultaneously
  - Slopes-as-outcomes

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Contextual Models

- No linkage b/w level 1 and level 2 = fixed effects
  - regardless of whether one model is fit or each group's model is fit
- Inferences:
  - the level 2 population
  - the level 1 population
- Random coefficients model:
  - level 1 coefficients are random at level 2
  - Level 1 coefficient originates from a probability distribution

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Two Perspectives on (Multilevel) Dependency

- As a **Nuisance**
- Observations should be sampled independently
  - Random sampling with replacement from an infinite population
  - Multi-stage sampling
    - Two-stage sample: only one subpopulation level
    - More cost-efficient
    - Population of interest contains subpopulations where selection takes place
    - Always requires multilevel analysis (at least initially)
- Common mistake:
  - Ignore that the sampling is two-stage
  - Selecting a primary unit increases the chance of selecting a secondary unit from that primary unit
    - ***Leads to dependent observations***

- As an **Interesting Phenomenon**
- We commonly want to make inference at both the macro and micro levels
- Macro-level units
  - Macro-units
  - Primary units
  - Clusters
  - Level-2 units
- Micro-level units
  - Micro-units
  - Secondary units
  - Elementary units
  - Level-1 units

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Ignoring Multilevel Structures

- Ecological fallacy:
  - apply group level results to the individual level
  - Type I error rate is inflated b/c analyses are based on too many degrees of freedom that are not truly independent

- Atomistic fallacy:
  - interpret individual-level analyses at the group level
  - Less common
  - Usually results in decreased power & loss of information b/c unit of analysis for the error term is the group rather than the individual

- Robinson (1950)

- Disaggregation:
  - higher level characteristics are assigned to lower level units
  - If we know a student is in the same class, then we know that student's characteristic, violating the independence assumption

- Aggregation:
  - average across units within a group and model the between-group differences only, perhaps weighted by group size
  - Throw away all the within-group information which may be a majority of the information
  - Consequentially, aggregate variable relations are deceptively strong and may vary substantially from disaggregated relationships

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Examples of Interesting Phenomena

- Macro-level
  - Schools
  - Classes
  - Neighborhoods
  - Firms
  - Jawbones
  - Families
  - Litters
  - Doctors
  - Subjects
  - Interviewers
  - Judges
- Micro-level
  - Teachers
  - Pupils
  - Families
  - Employees
  - Teeth
  - Children
  - Animals
  - Patients
  - Measurements
  - Respondents
  - Suspects

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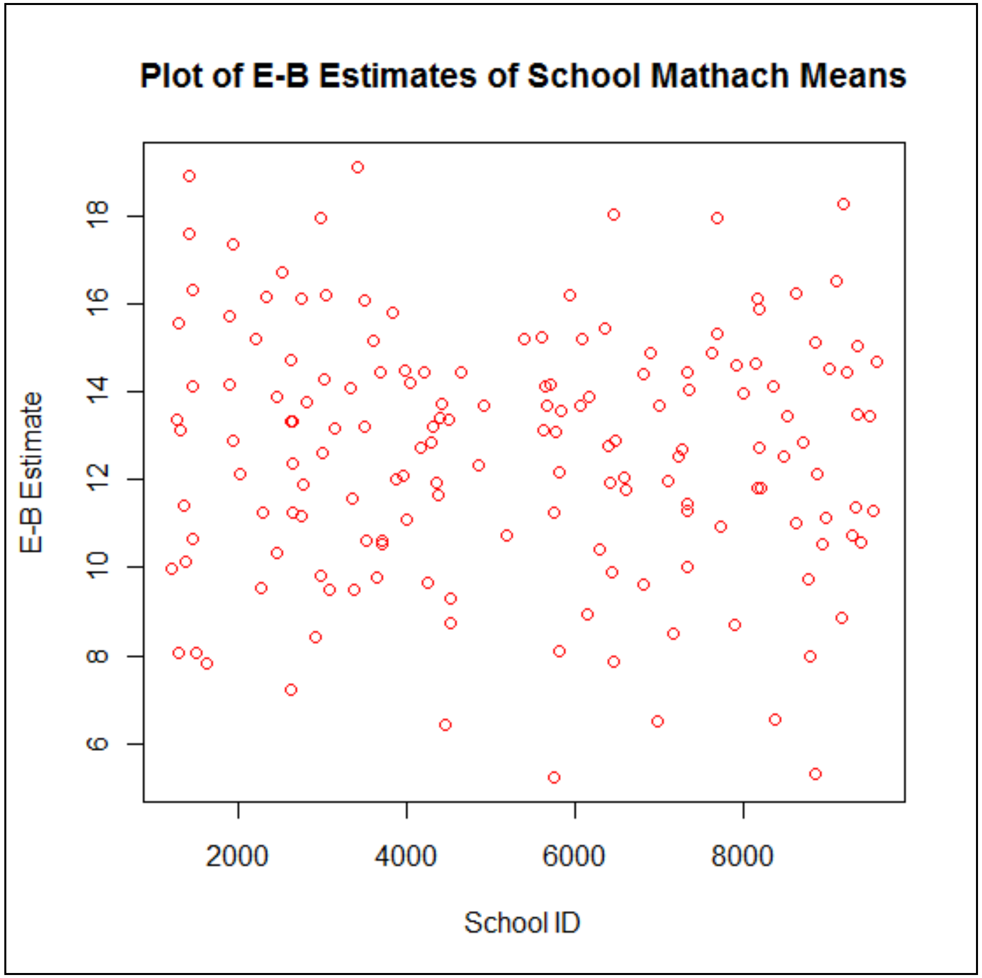
Math Achievement

- We know that student level and school level *math achievement* vary in the population

- Why do they vary?

- <u>Hypothesis</u>: SES explains some of the variance in math achievement.



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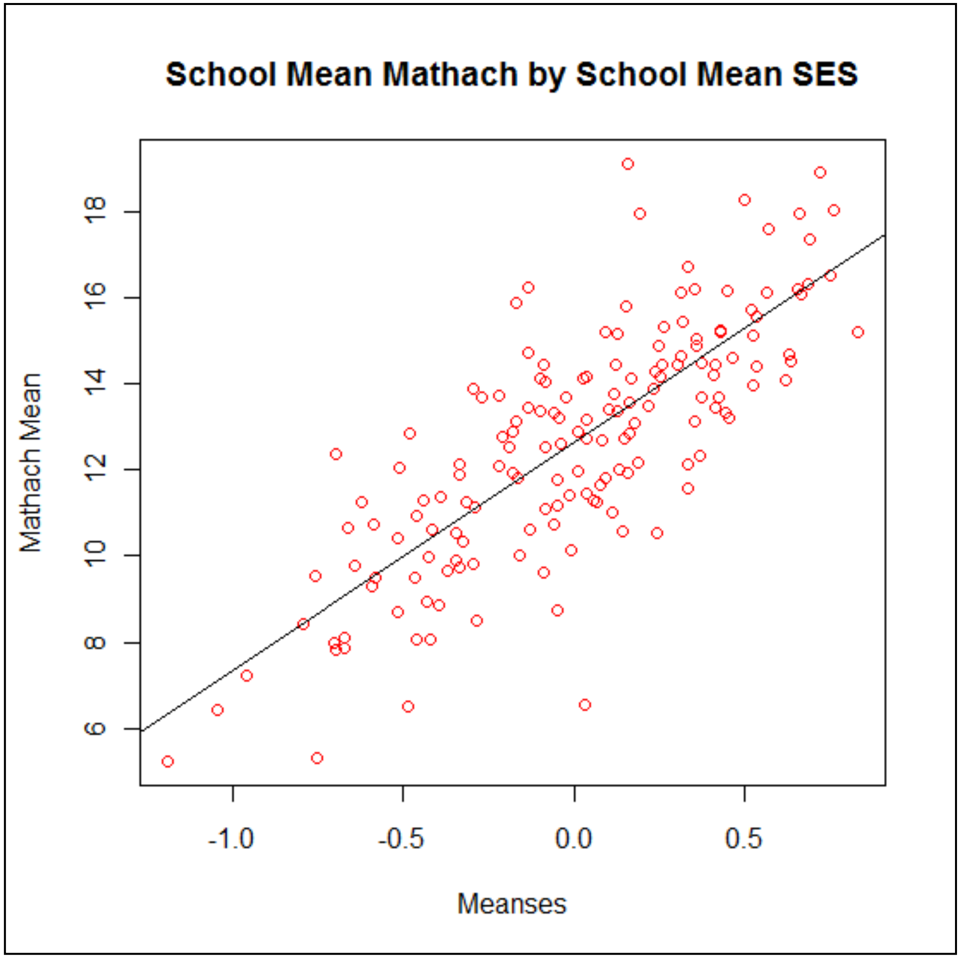
Math Achievement at the School Level

•Note that we're looking at the *between-school relationship* between SES and *mathach*.

•It's the relationship between the school-level predictor (*meanses*) and the school-level outcome (school mean *mathach*).



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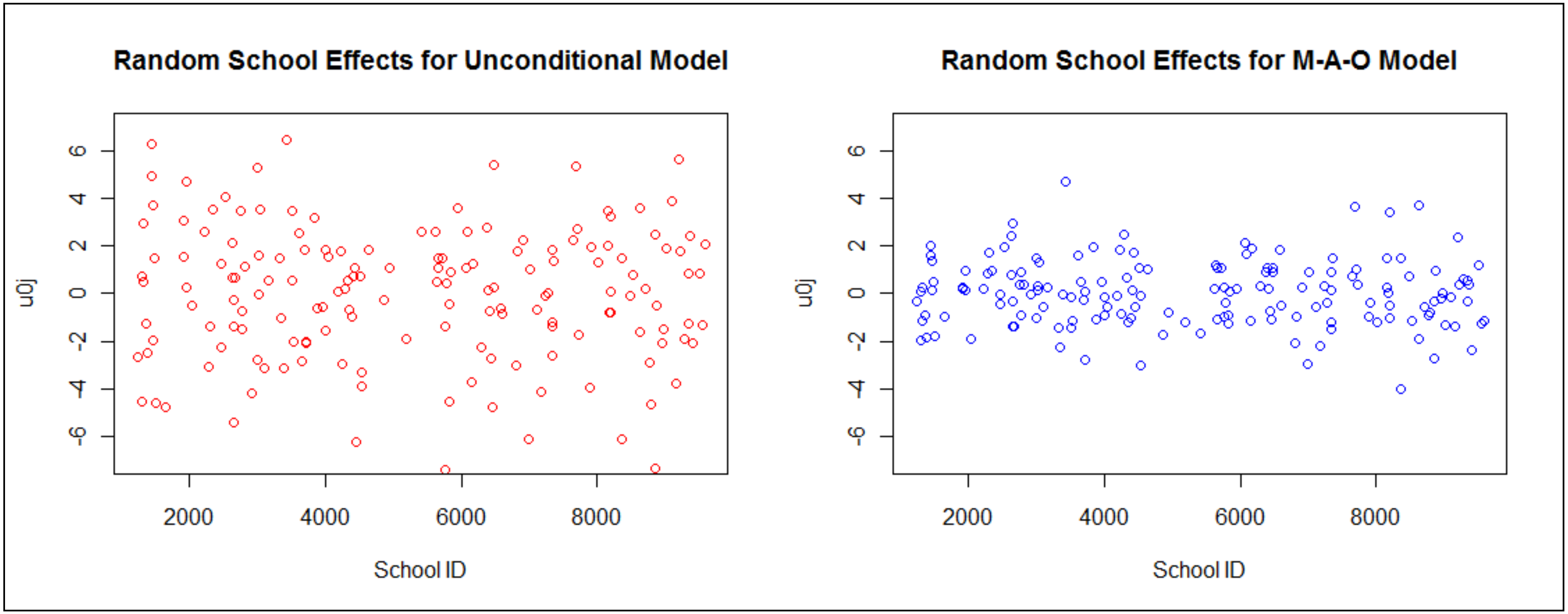
Proportion of Variance Explained

Here are the level-two residuals for the unconditional and M-A-O models.



Note the clear reduction in the variance. Also note there is still variance among school means, (recall, $\tau_{00} \neq 0$).

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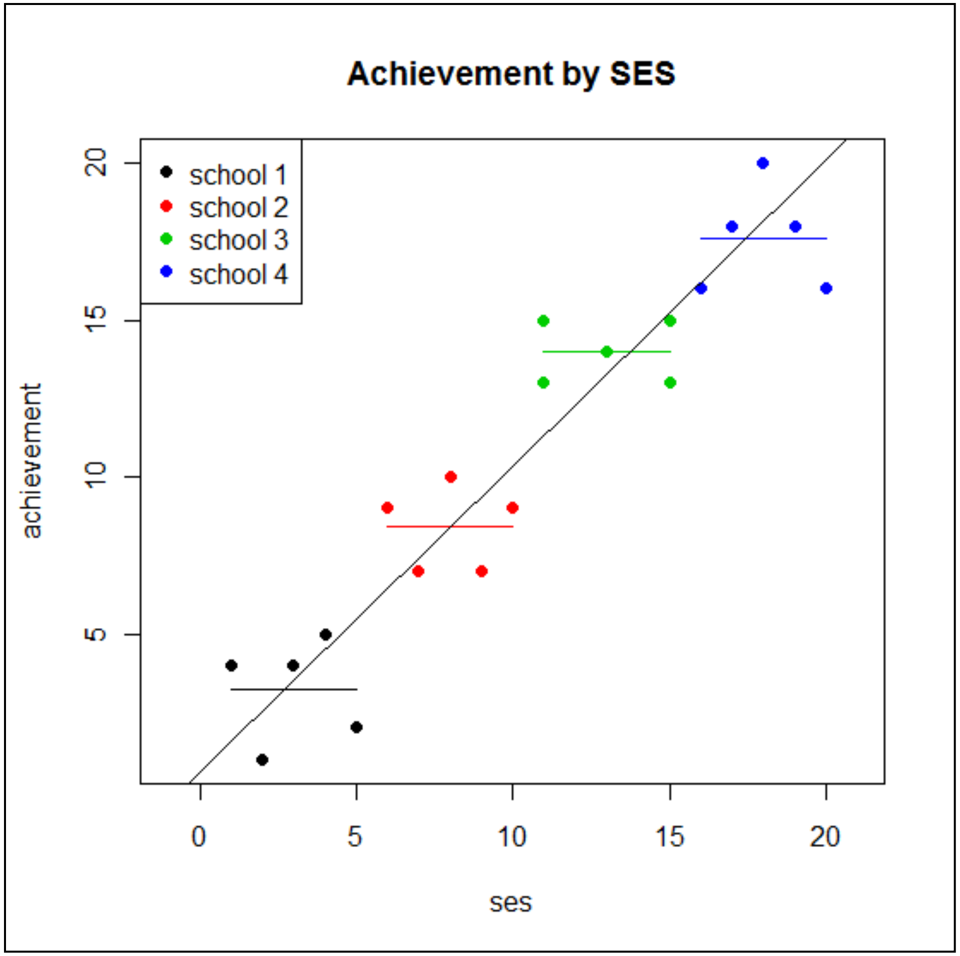
Disentangling School and Student Level

•Within-context relationships and between-context relationships are not always the same.

•We should look at them separately.

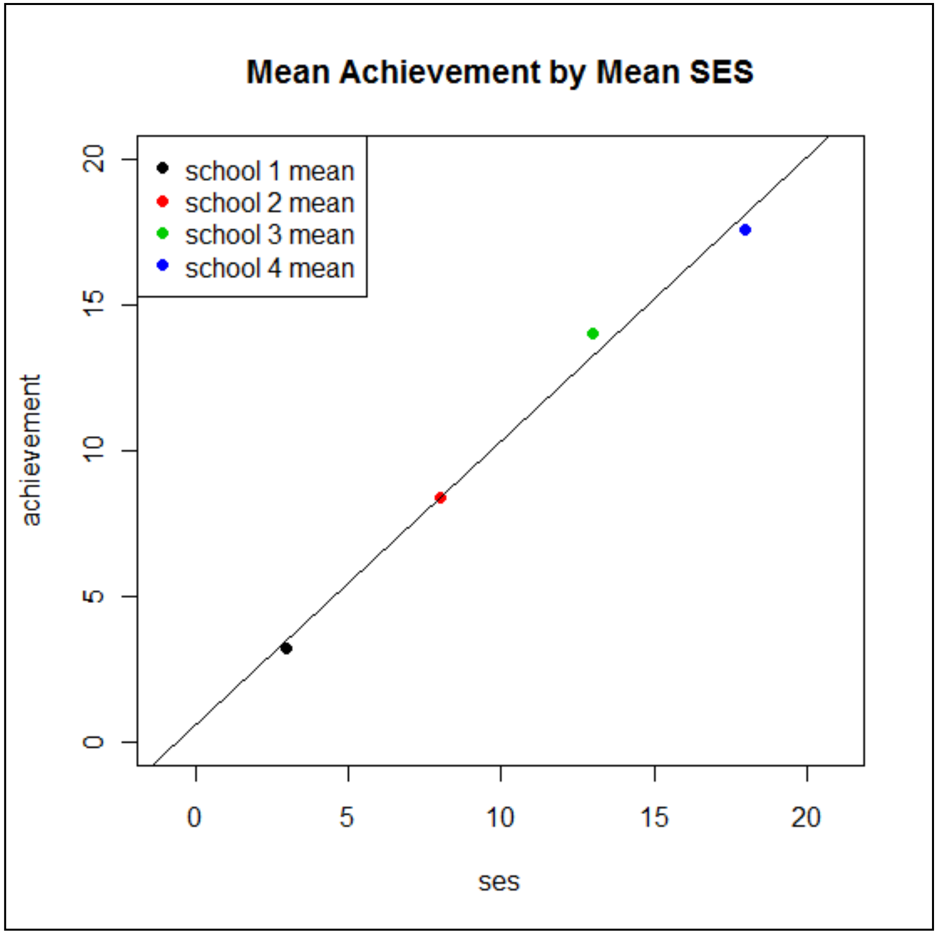
•SES is usually measured at the individual/family level.

– Context-level SES is usually an aggregate of its members OR measured in a different way altogether.



Disentangling School and Student Level

- We can use a *means-as-outcomes* approach to look at the between-school relationship between Math Achievement and SES.



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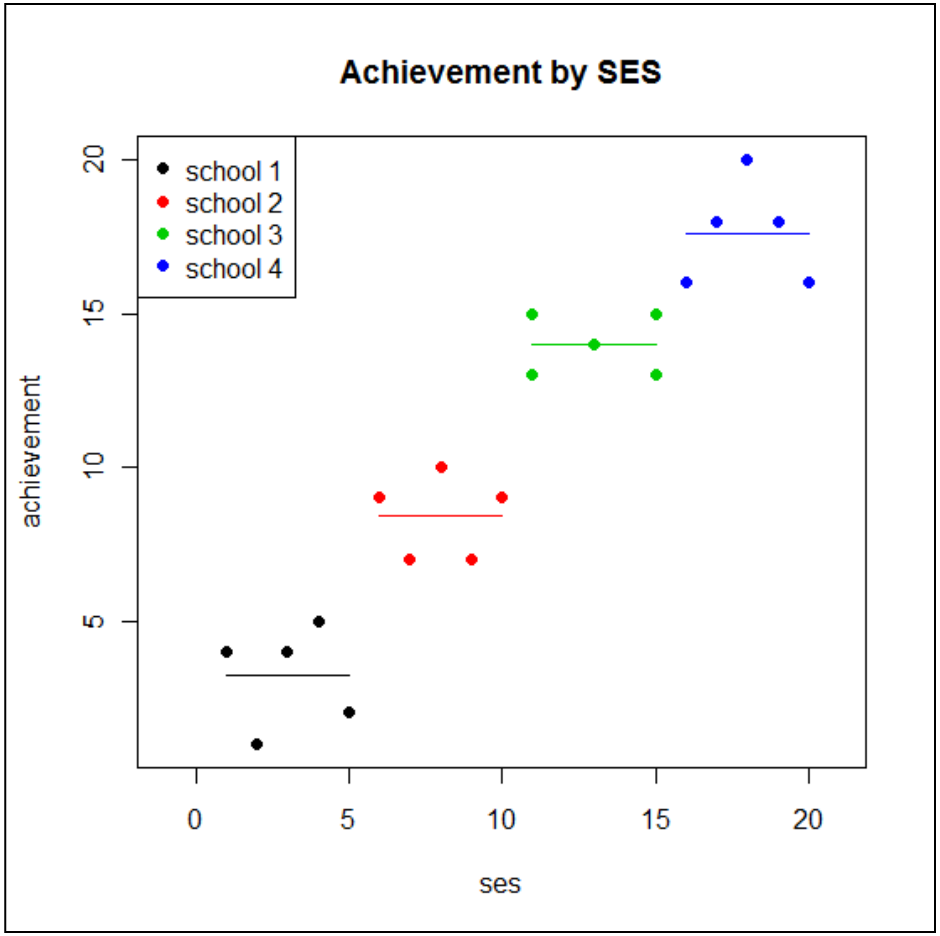
Disentangling School and Student Level

- We can use a *random coefficients* approach to look at within-school relationships.



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Disentangling School and Student Level

- Looking at within-context relationships depends on how we operationalize within-context versus between-context explanatory information.

- When you add level-one (within-context) explanatory variables, *centering* is very important.

- There are two ways to center a level-one explanatory variable:
  - Grand mean centering
  - Group mean centering

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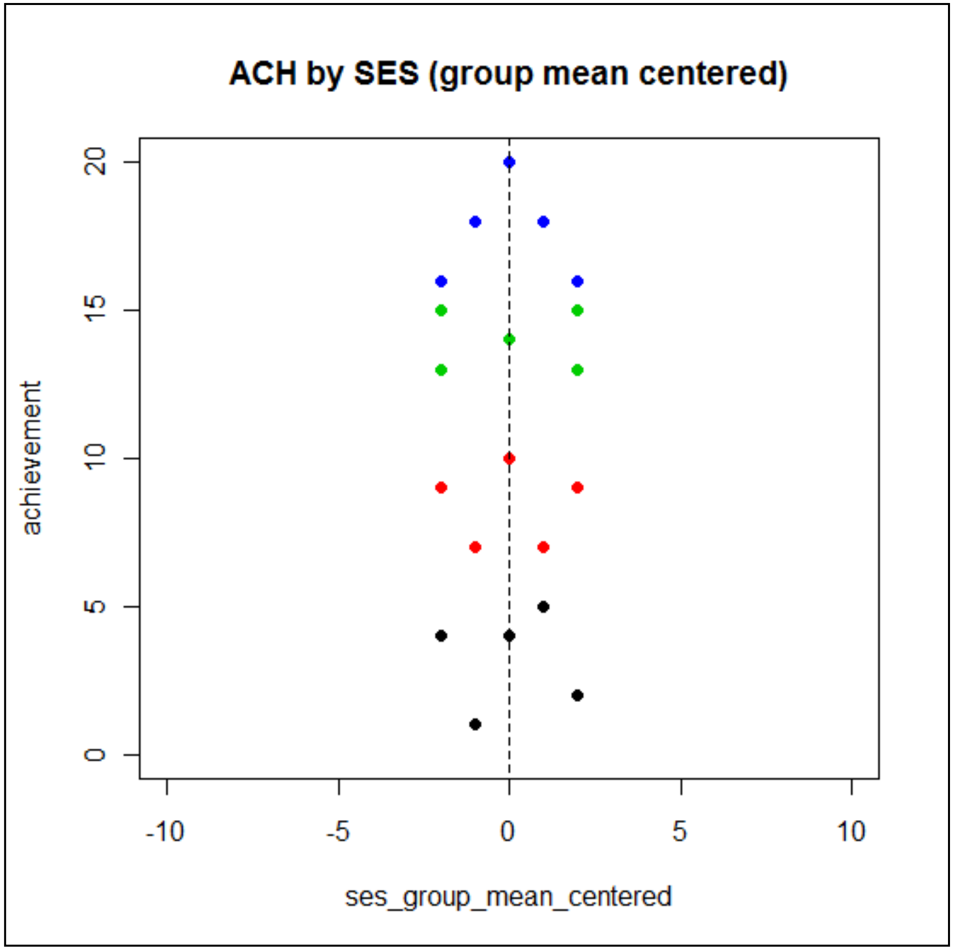
Disentangling School and Student Level

•Here are the data under ***group mean*** centering:

•The mean SES for each school is brought to zero.

•This "removes" any between-school differences on SES.



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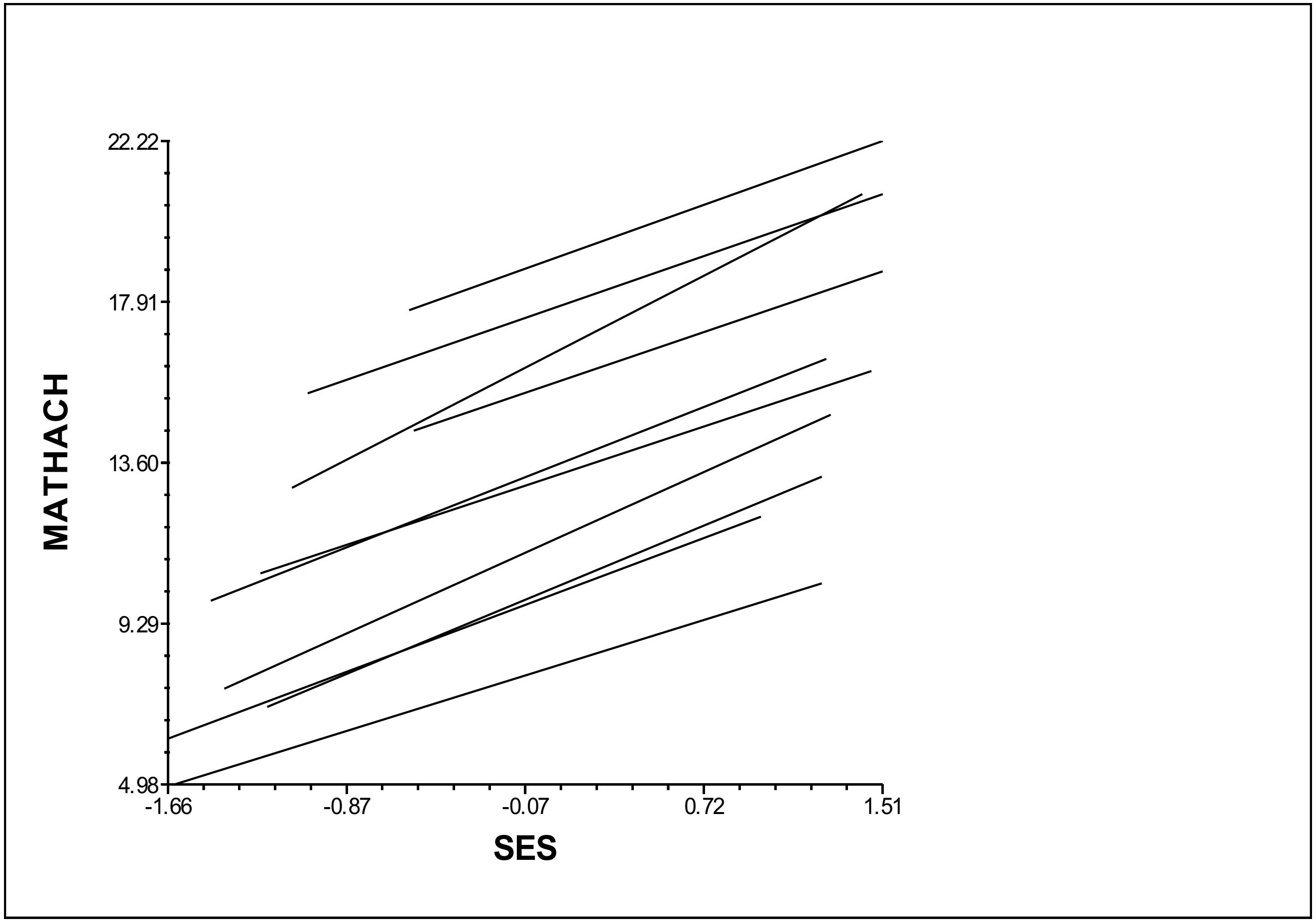
Disentangling School and Student Level

We're letting each school have its own regression equation.



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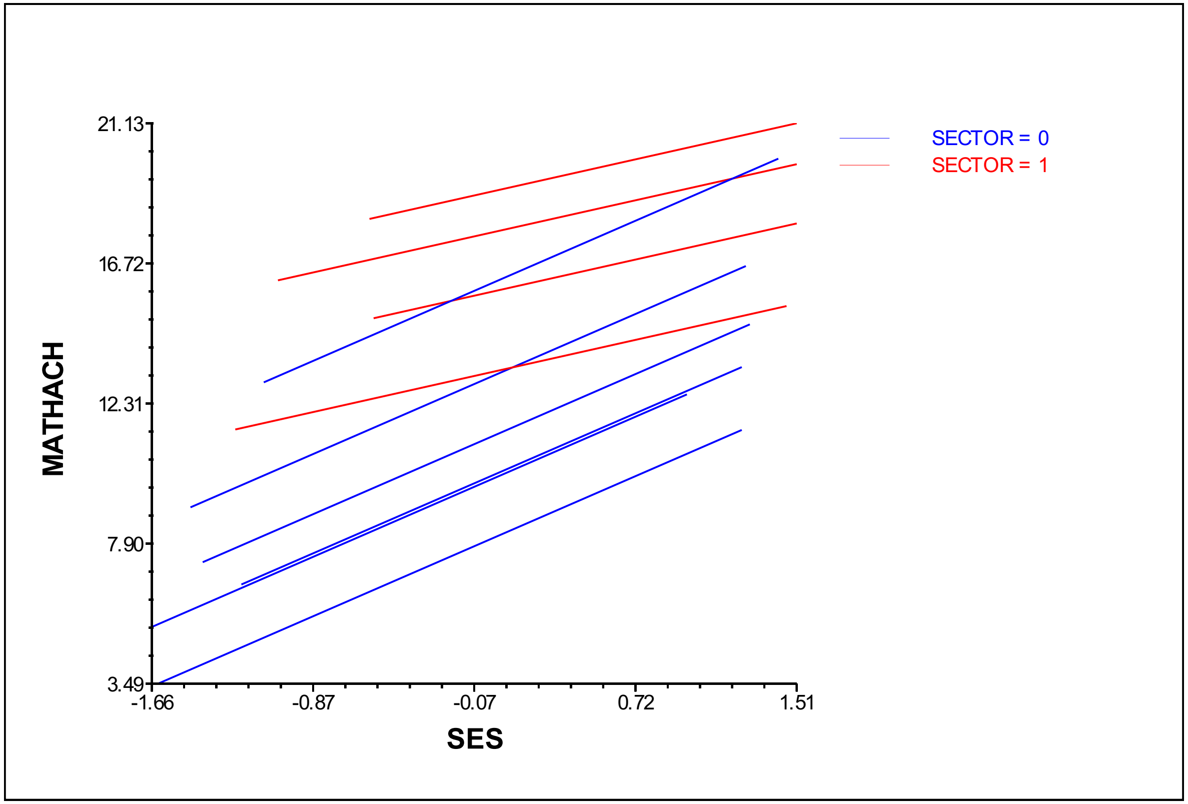
Disentangling School and Student Level

- When we also consider what ***type*** of school (public versus Catholic) each contextual unit is…

- All **public schools** are forced to have the same SES-*mathach* slope.

- All **catholic schools** are forced to have the same SES-*mathach* slope.



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The "Contextual Effect"

The "contextual effect" for SES…

Fixed Effect	Coefficient	Standard error	*t*-ratio	Approx. *d.f.*	*p*-value
For INTRCPT1, β_0					
INTRCPT2, γ_{00}	12.648405	0.148410	85.226	158	<0.001
MEANSES, γ_{01}	5.865602	0.359360	16.322	158	<0.001
For SES slope, β_1					
INTRCPT2, γ_{10}	2.191172	0.108660	20.165	7024	<0.001

…can be calculated as the difference between the between-school slope and the within-school slope:

contextual effect = $\gamma_{01} - \gamma_{10}$ = 5.86 – 2.19 = 3.67

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The "Contextual Effect"

Under grand mean centering, γ_{01} is the contextual effect:

Fixed Effect	Coefficient	Standard error	*t*-ratio	Approx. *d.f.*	*p*-value
For INTRCPT1, β_0					
INTRCPT2, γ_{00}	12.661864	0.148413	85.315	158	<0.001
MEANSES, γ_{01}	3.674465	0.375431	9.787	158	<0.001
For SES slope, β_1					
INTRCPT2, γ_{10}	2.191165	0.108660	20.165	7024	<0.001

After controlling for student SES, the **effect of *meanses* is γ_{01} = 3.67**. This is the contextual effect.

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Types of Contextual Models

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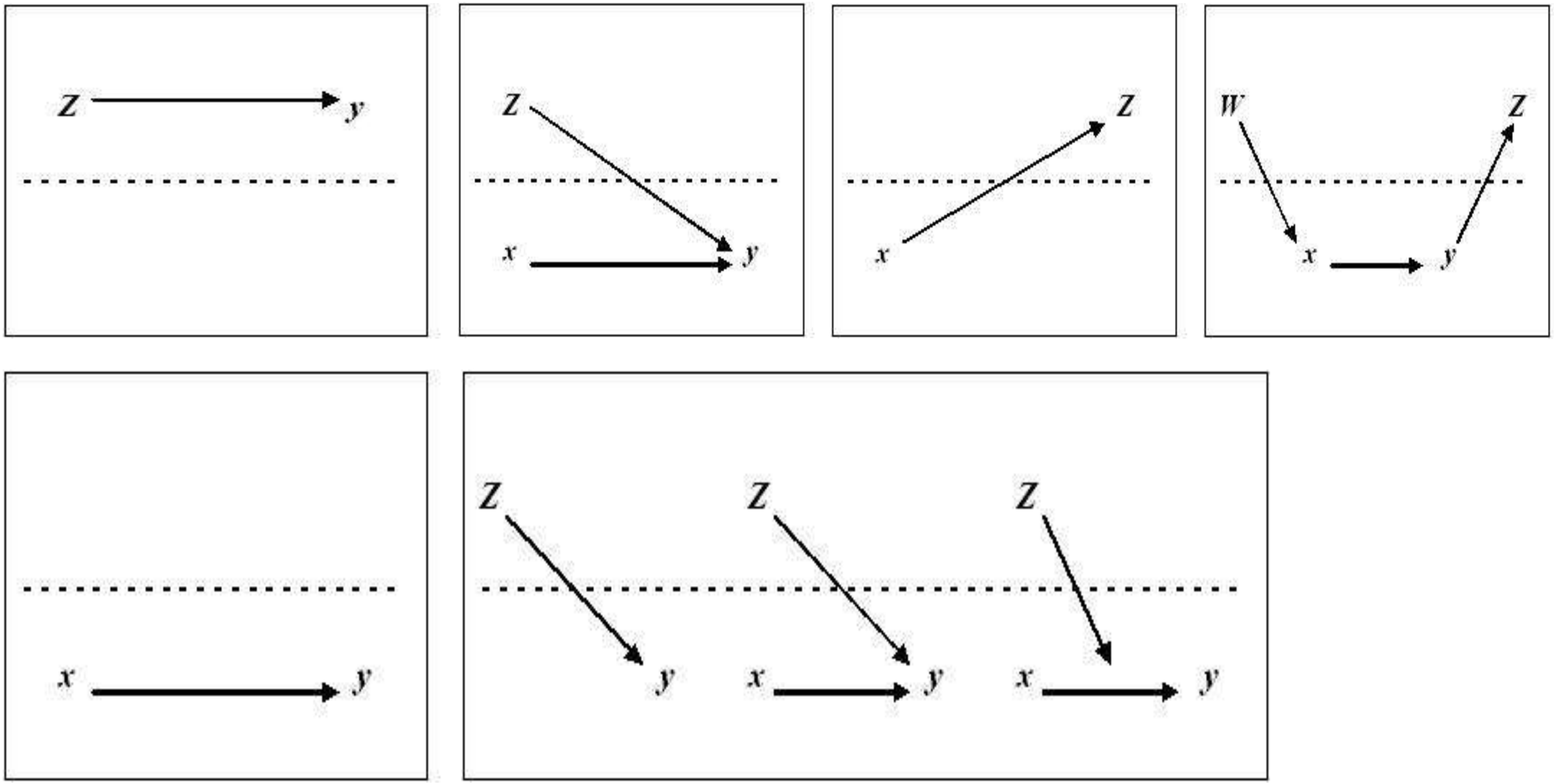
Types of Relationships

- Tacq (1986): 3 propositions
  - Macro-unit
  - Micro-unit
  - Macro-micro relations

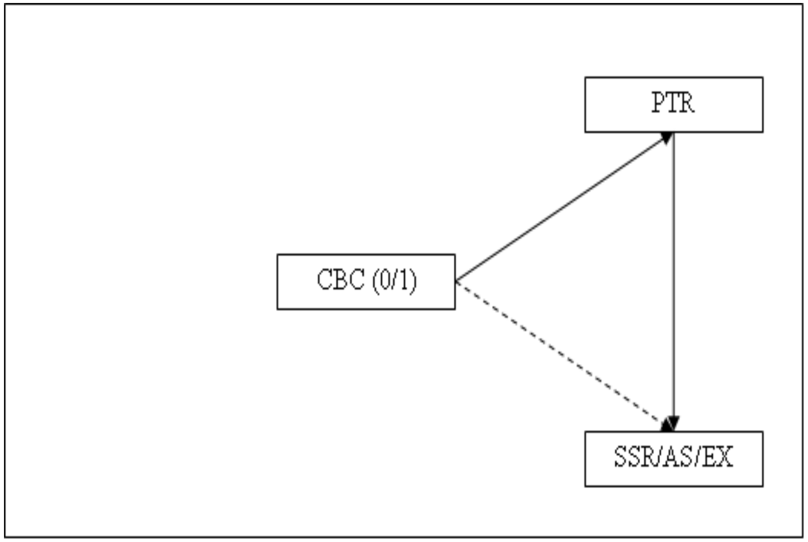
- Emergent (micro-macro) proposition
- Causal chain propositions

Types of Relationships (Cont.)



A Macro-Micro Proposition: Multilevel Mediation

- Mediator
  - PTR = parent-teacher relationship
- IV
  - CBC = intervention
- DV(s)
  - SSR = social skills (+)
  - AS = adaptive skills (+)
  - EX = externalizing behaviors (-)



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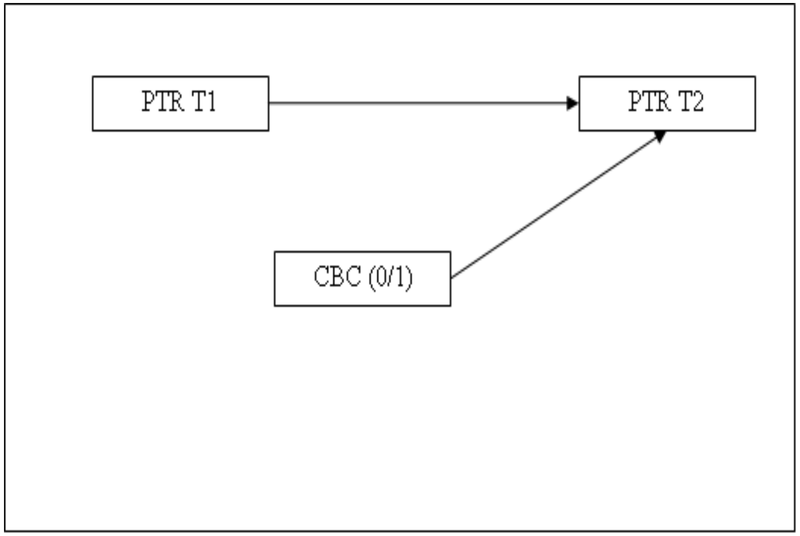
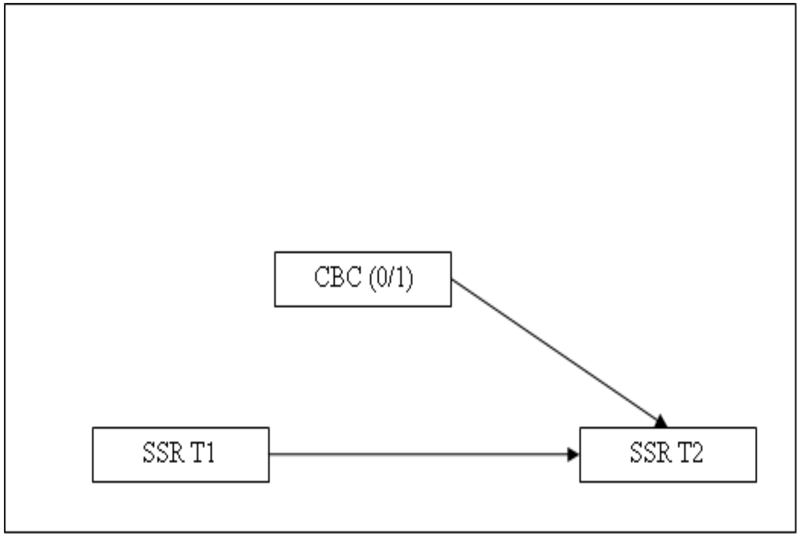
Longitudinal Component





- But there is change over time
  - T1 = pre-test
  - T2 = post-test
- Rather than a LGM…
  - mean differences at post-test conditional upon pre-test levels

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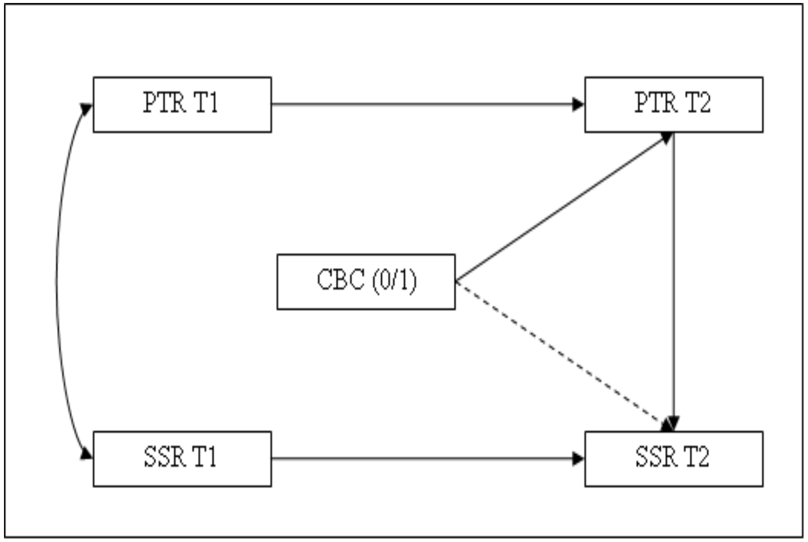
Overall Model

- Implementation of the CBC intervention leads to a change (i.e. mean difference) in the parent-teacher relationship at post-test.
- Improved parent-teacher relationship translates to higher levels of social skills at post-test.
- Students in the CBC condition show increased social skills (vs. students in the control condition) at post-test, but it is due to an improvement in the parent-teacher relationship.



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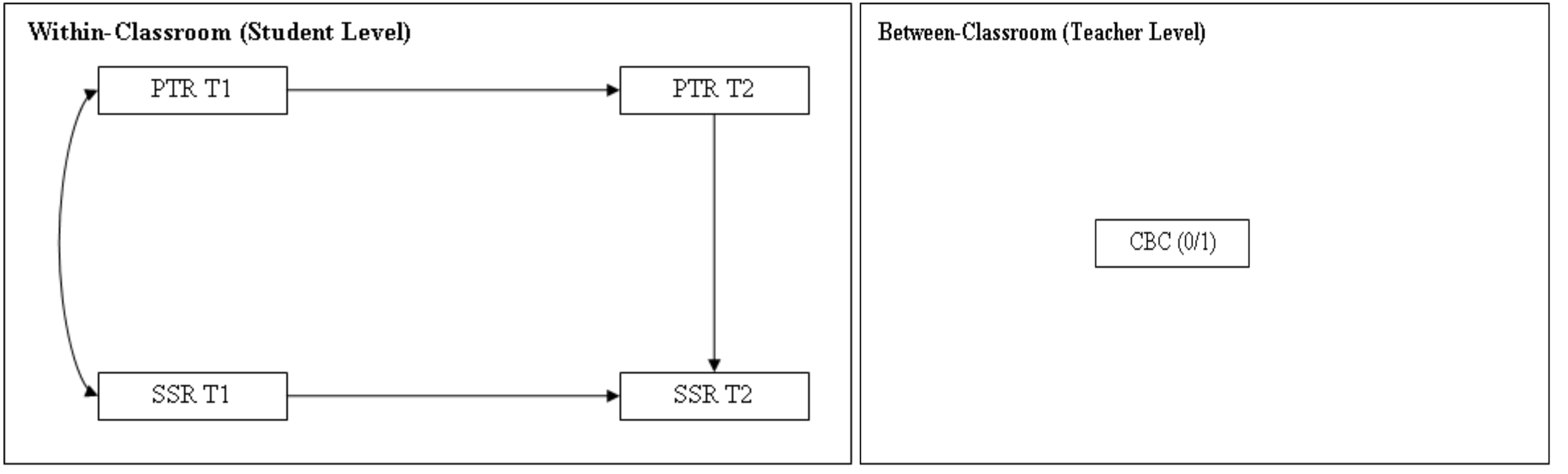
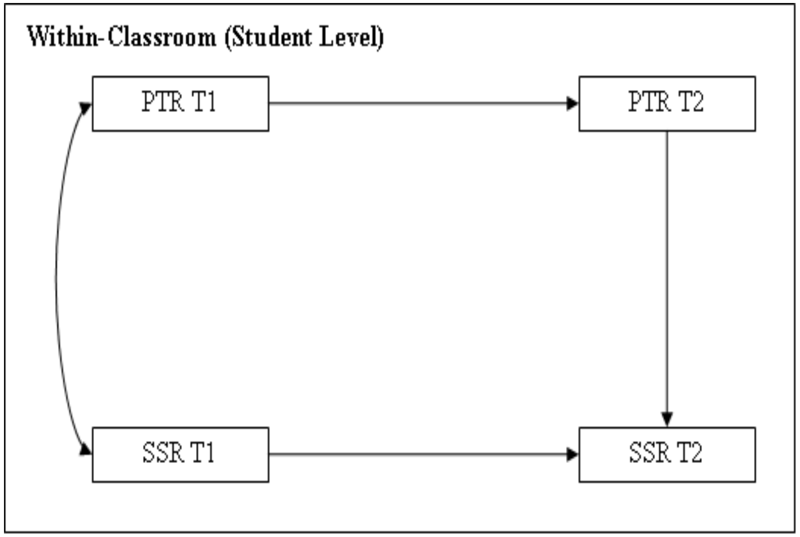
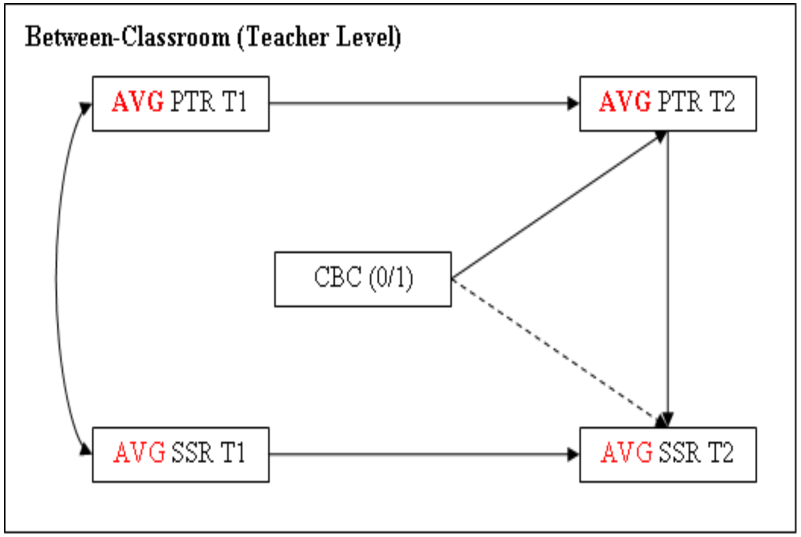
Complex Sampling



- But 2-3 students per classroom are identified for exhibiting disruptive behaviors
  - Students nested within classrooms/teachers
  - Nuisance variance at level 2
- Classrooms are assigned to condition
  - Interesting thing(s) at level 2

Something Interesting at Level 2





- Number of clusters = 83
- Average cluster size = 2.301

- Estimated ICCs
  - PTR2 0.308
  - SSR2 0.361
  - PTR1 0.306
  - SSR1 0.339

- There is between-teacher variance on all outcomes
  - So allow PTR 1 & 2 and SSR 1 & 2 to be **both** *within* & *between* variables

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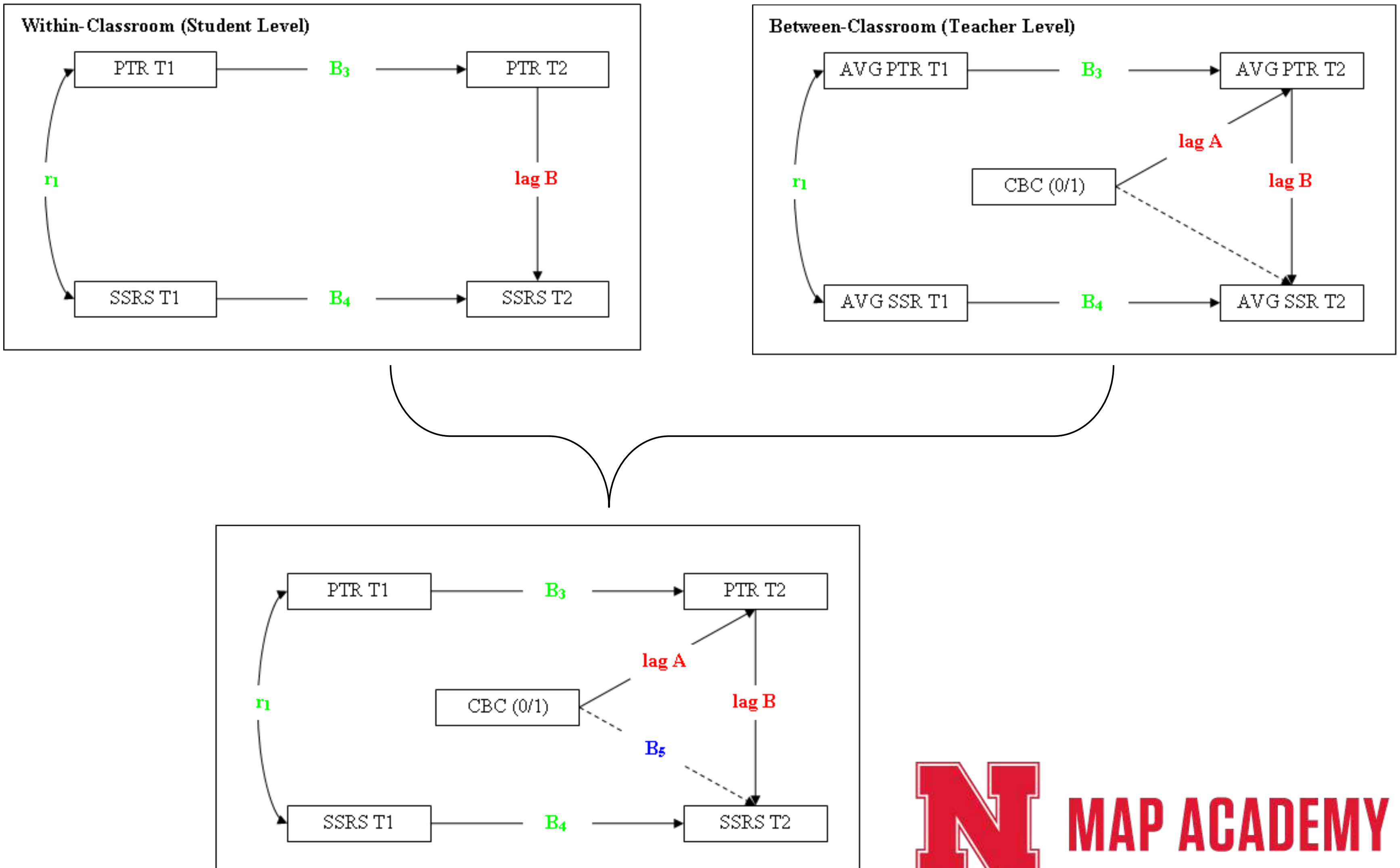
Conceptual Model as a Two-Level Ecological Model



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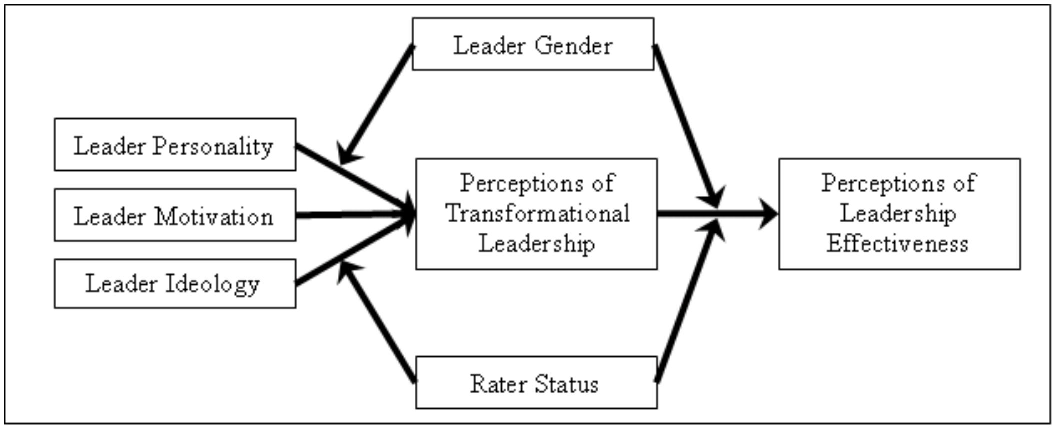
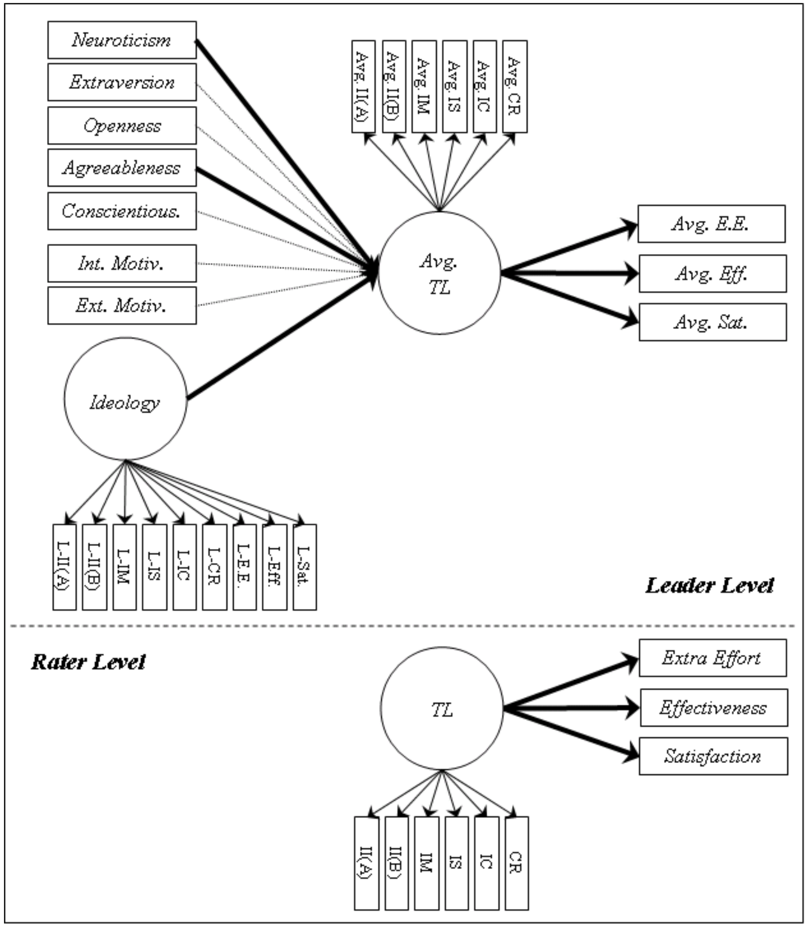
Macro-Macro-Micro Model of Leadership Effectiveness





From: Barbuto, J.E. Jr., Bugenhagen, M.J., & Bovaird, J.A. (under revision). *Testing A Model For Predicting College Student Leadership Behaviors: A Multi-level Analysis*.

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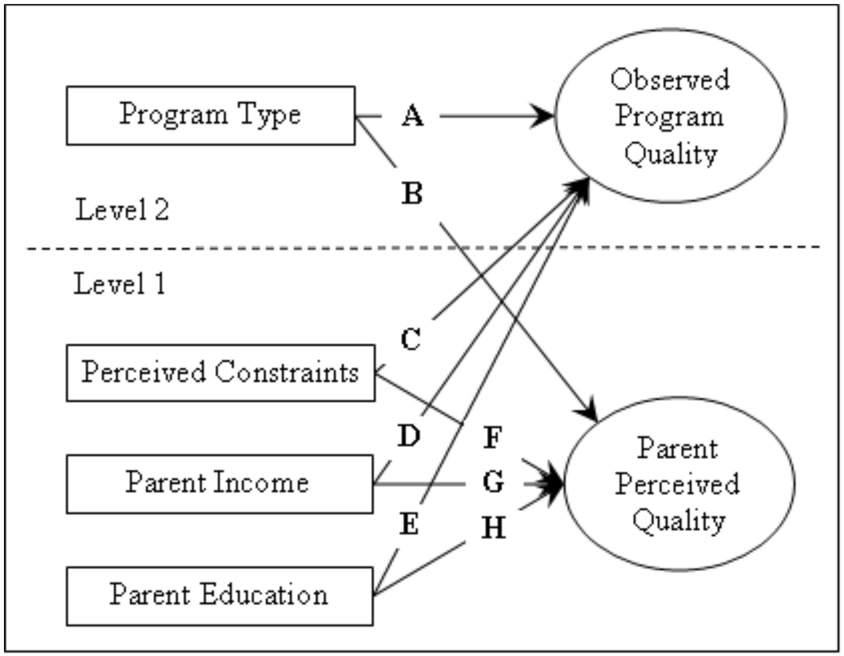
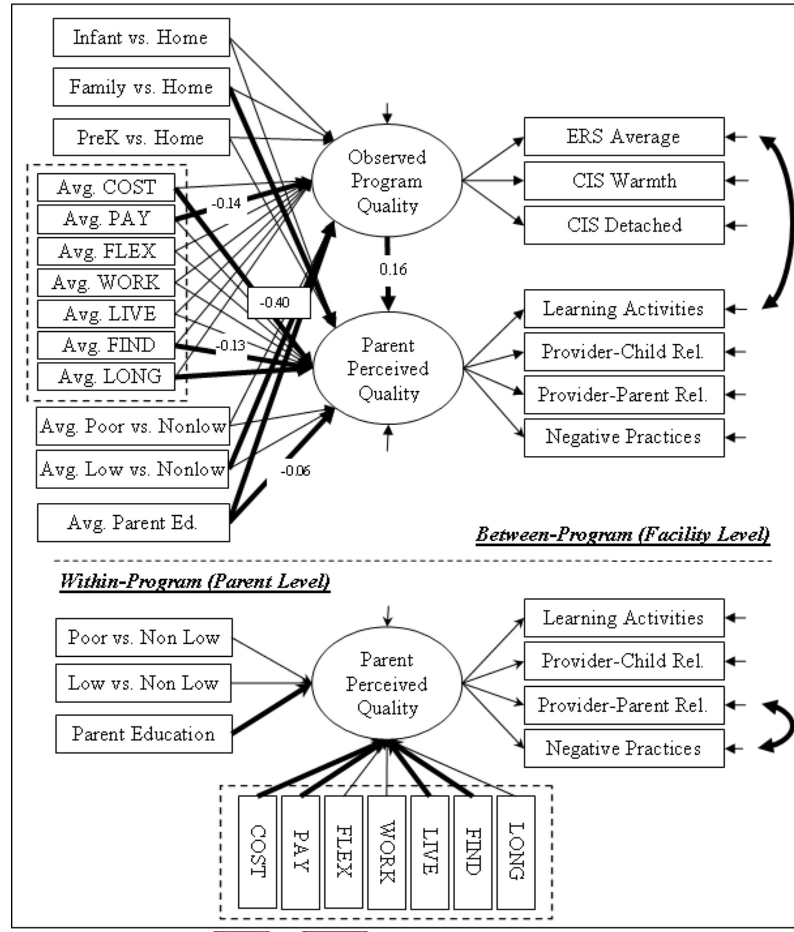
Micro-Macro & Macro-Micro Model of Program Quality





From: Torquati, J.C., Huddleston-Casas, C., Raikes, H., Bovaird, J.A., & Harris, B.A. (under revision). *Quality of Child Care for Low-income Children: Still Inequity*.

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School Readiness – Incorporating Macrosystems and Exosystems

Figure 1. Conceptual drawing of the model of student readiness.

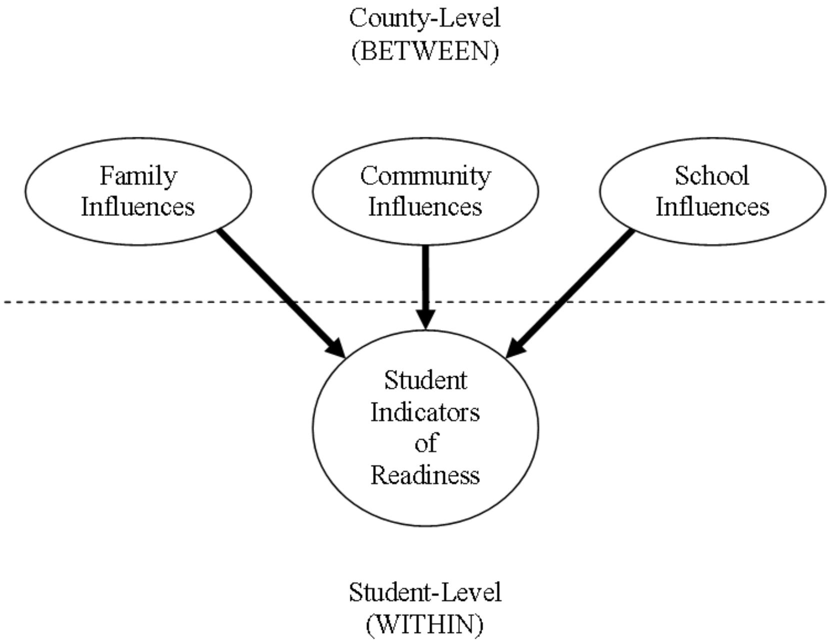
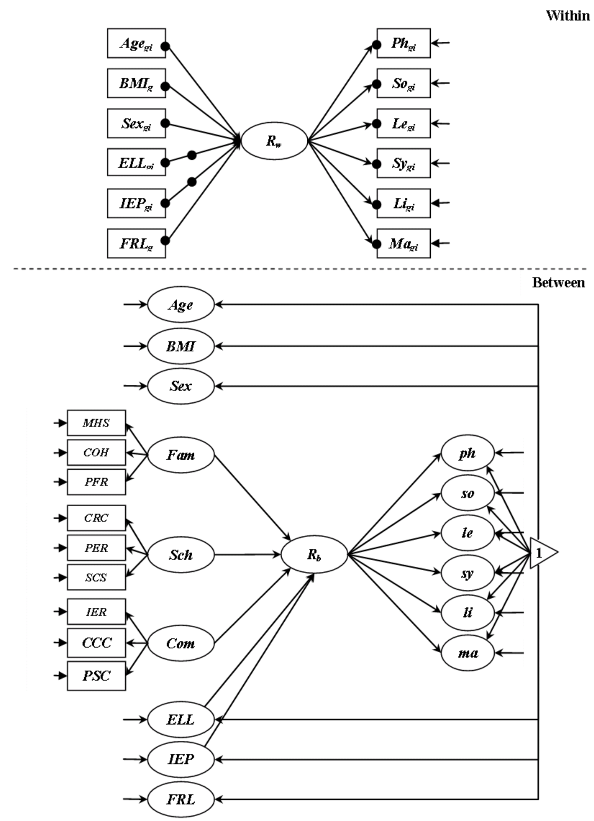


Figure 2. MSEM of kindergarten readiness.



From: Bovaird, J.A., Martinez, S., & Stuber, G. (2006, August). *Multilevel Structural Equation Modeling of Kindergarten Readiness with Finite Samples.* Paper presented at the American Psychological Association annual meeting. New Orleans, LA.

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NEBRASKA ACADEMY FOR
METHODOLOGY, ANALYTICS & PSYCHOMETRICS

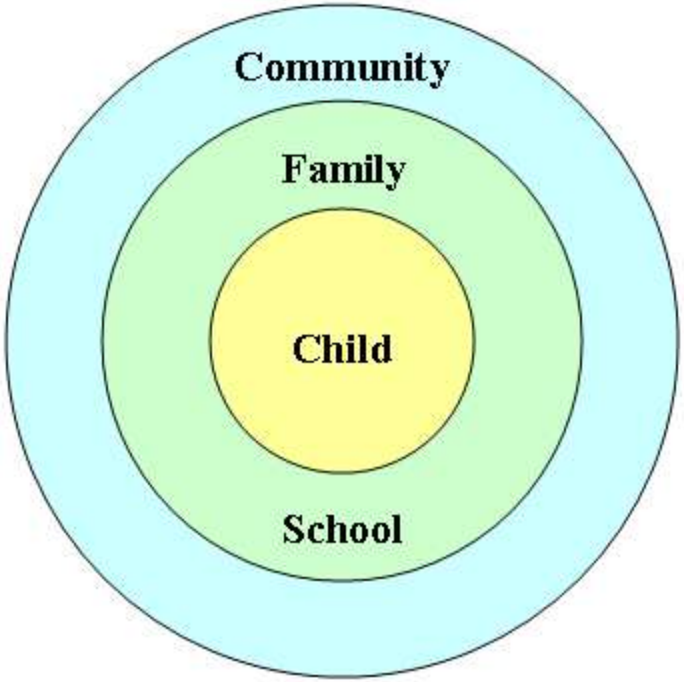
Kansas School Readiness Project

University of Nebraska Lincoln

Kansas Vision for School Readiness

- *The Kansas Vision for School Readiness*
  - *School Readiness occurs when families, schools, and communities support and serve children effectively so that all children have the ability to succeed in various learning environments.*

- The Kansas Coalition for School Readiness defines school readiness in this way:
  - "School readiness requires more than just knowing letters and numbers. A child must be healthy. Prepared to sit in a class and listen to instructions. To cooperate with peers. And be curious."
    - http://readyornotks.org/



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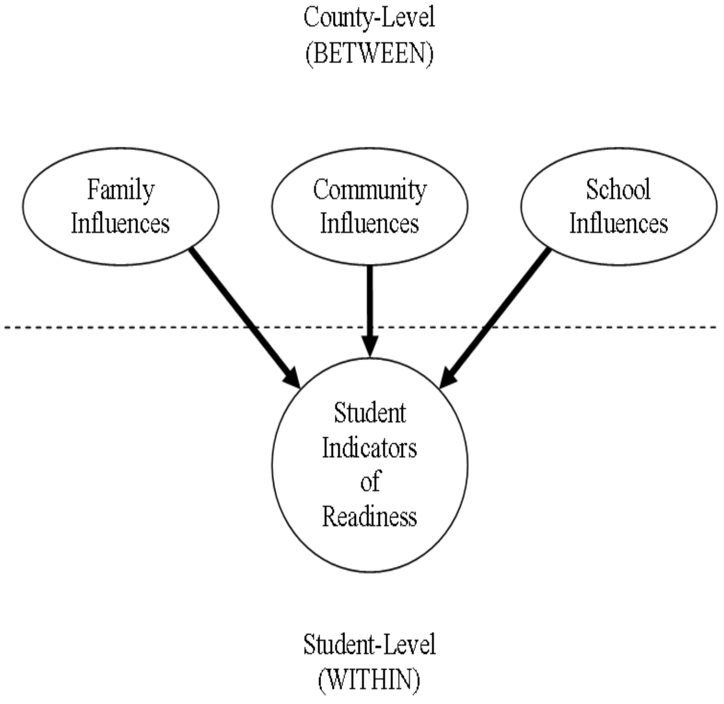
Kansas Kindergarten Readiness Project: Student Readiness for School

- Cross-sectional contextual (county) model of (student) school readiness
  - Bovaird (2005); Bovaird, Martinez, & Stuber (2006)
  - Multilevel model is appropriate
    - *students nested within county*
- Goal:
  - To describe the relationship between county-level contextual characteristics and kindergarten preparedness, controlling for student-level characteristics.

Figure 1. Conceptual drawing of the model of student readiness.



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Kansas Kindergarten Readiness Project

- *Kansas School Entry Assessment*
  - Teacher-completed measure of kindergarten preparedness
  - Modification of the *Kansas School Entry Assessment* pilot instrument & the *School Entry Assessment Project* instrument (Missouri Department of Elementary and Secondary Education)
  - 41 items in 6 areas of school readiness:
    - symbolic development (Sy) – 7 items
    - literacy development (Li) – 10 items
    - mathematical knowledge (Ma) – 7 items
    - social skills development (So) – 8 items
    - learning to learn (Le) – 6 items
    - physical development (Ph) – 3 items
  - Student-level measures:
    - age (Age)
    - body-mass index (BMI)
    - gender (Sex)
    - language status (ELL)
    - eligibility for free or reduced lunch (FRL)
    - IEP status (IEP)

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Kansas Kindergarten Readiness Project

- **21 county-level contextual variables supplied by state agencies**
- grouped into three goal areas:
  - **Family Goal**
    - children live in safe and stable families that support learning
  - **Community Goal**
    - children live in safe and stable communities that support learning, health, and family services
  - **School Goal**
    - children attend schools that support learning

Kansas Kindergarten Readiness Project

- The data
  - ***N* = 1,997 kindergartners**
  - 1-2 kids per teacher (teacher IDs not tracked)
  - 233 schools (1-22 kids/school, avg = 6 kids/school)
  - 154 districts (1-35 kids/district, avg = 12 kids/district)
  - ***J* = 95 counties** (1-46 kids/county, avg = 21 kids/county)
    - Out of a possible 105 counties in Kansas

N MAP ACADEMY

Are There Contextual Differences in Readiness Measurement?

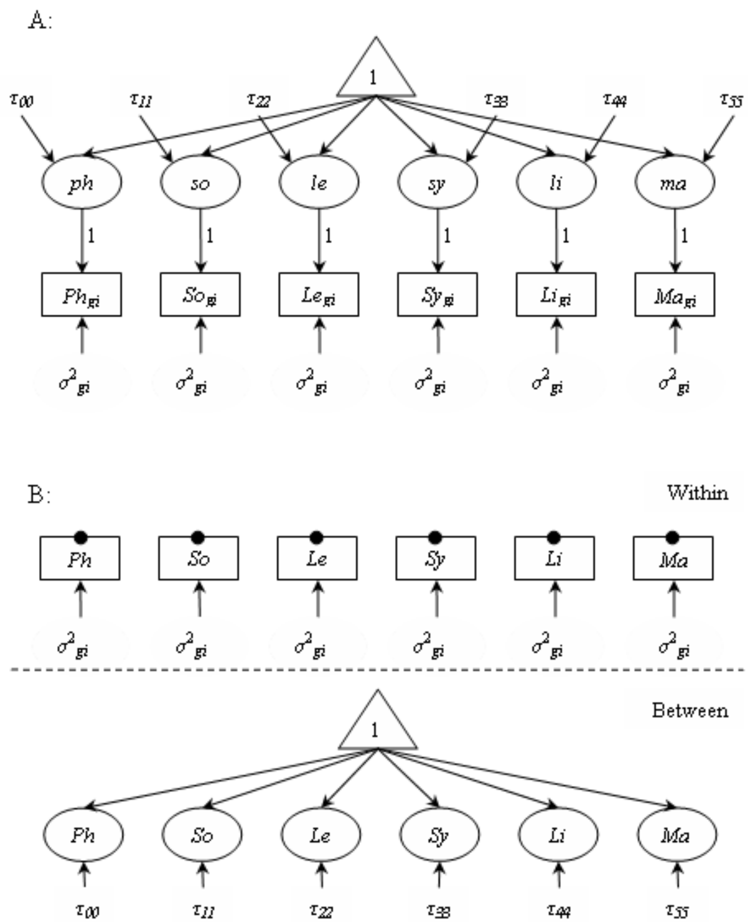

Table 1

Univariate Random-Intercepts Mixed-Effects Models: Fixed and Random Effects

Student-level variables	Intercept	SE	Between-county variance	SE	Within-county variance	SE	ICC	Sig.
Outcomes								
Physical	2.78	0.01	0.0042	0.0017	0.1392	0.0045	0.03	< .01
Social	2.67	0.02	0.0129	0.0033	0.1823	0.0059	0.07	< .01
Learning	2.69	0.01	0.0096	0.0027	0.1707	0.0055	0.05	< .01
Symbolic	2.65	0.02	0.0293	0.0059	0.1833	0.0060	0.14	< .01
Literacy	2.65	0.02	0.0218	0.0050	0.2185	0.0071	0.09	< .01
Math	2.69	0.02	0.0272	0.0056	0.2023	0.0066	0.12	< .01
Predictors								
Age	5.61	0.01	0.0068	0.0031	0.2641	0.0087	0.03	0.01
BMI	16.63	0.08	0.1661	0.0966	7.5139	0.2658	0.02	0.04
ELL	0.90	0.02	0.0240	0.0044	0.0595	0.0020	0.29	< .01
FRL	0.58	0.02	0.0195	0.0049	0.2248	0.0077	0.08	< .01
Sex	0.50	0.01	0.0001	0.0016	0.2500	0.0081	0.00	0.48
IEP	0.85	0.01	0.0080	0.0022	0.1174	0.0039	0.06	< .01

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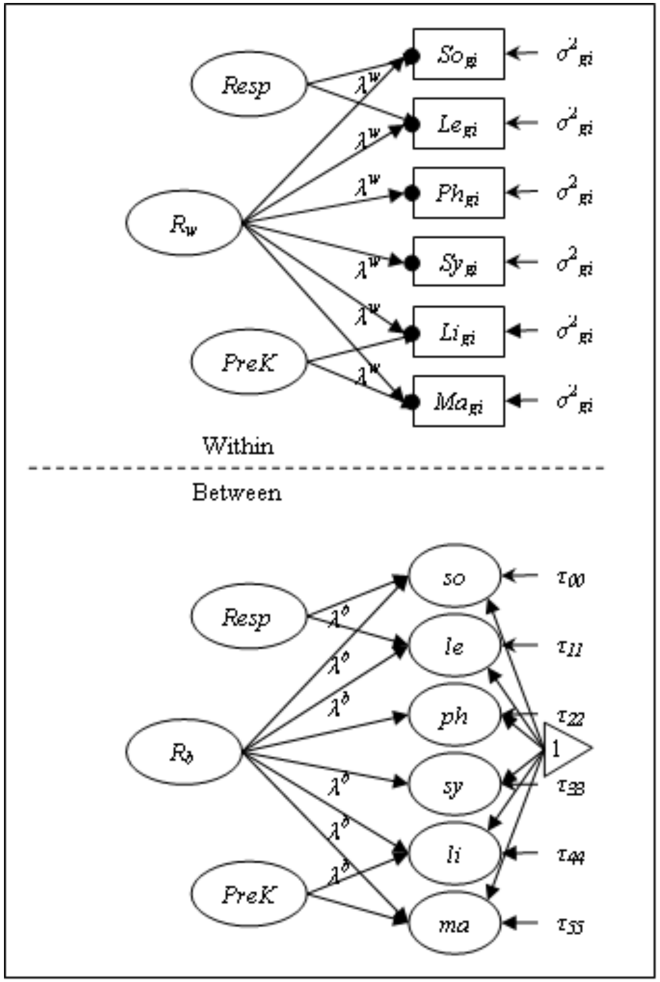
Multilevel Measurement Model



- Multilevel confirmatory factor analysis (MCFA) model of readiness for kindergarten.
  - $\chi^2(19) = 67.46$, $p < .01$
  - CFI = 0.991
  - RMSEA = 0.036

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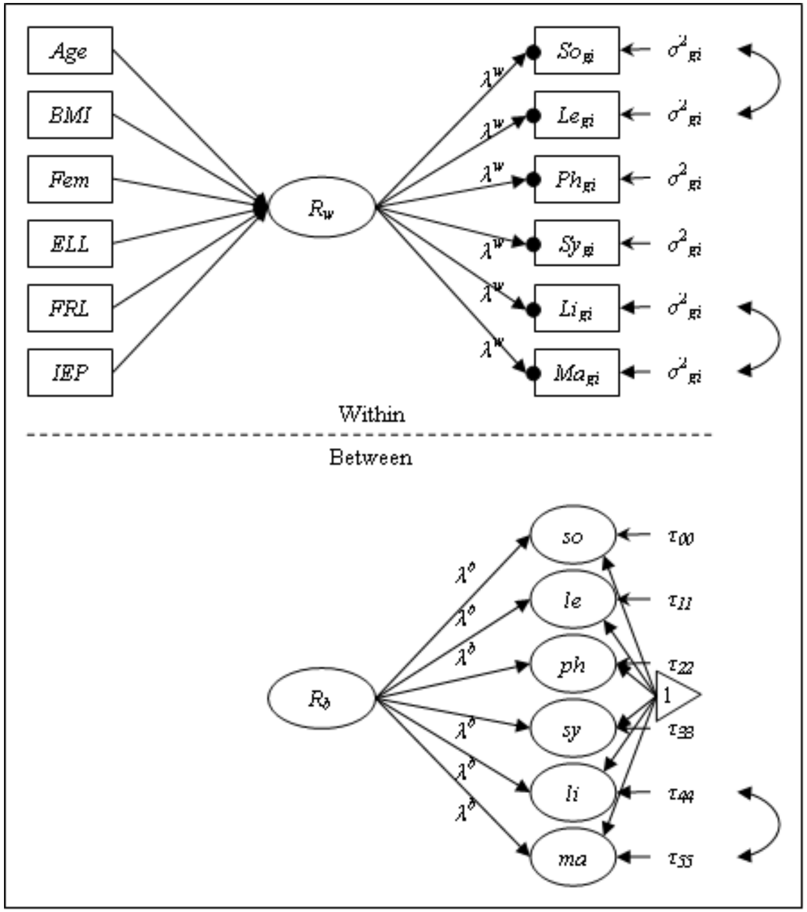
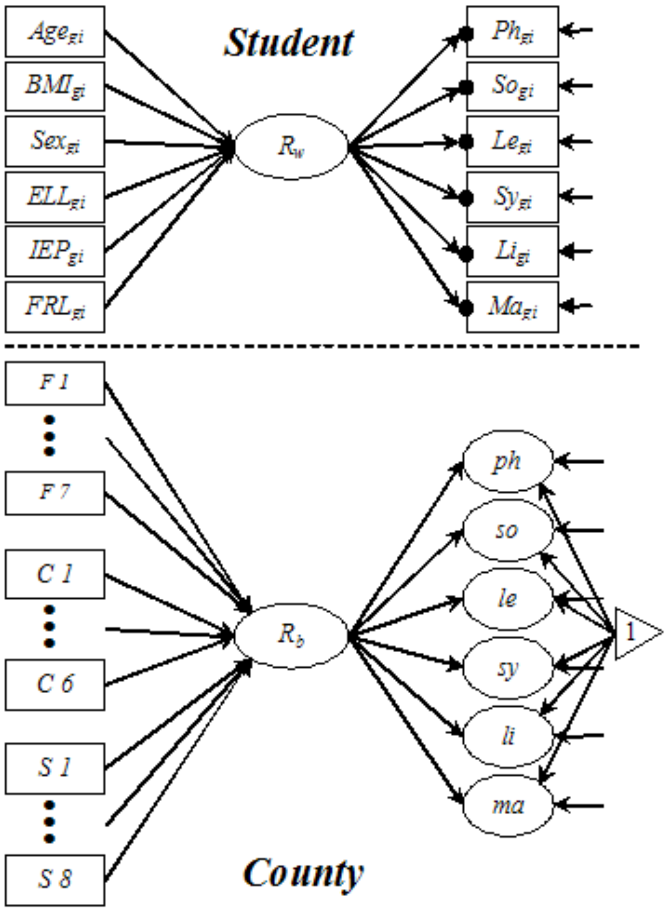
Multilevel MIMIC Model: Micro Level



- Multilevel multiple indicators multiple causes (M-MIMIC) model of readiness for kindergarten.
  - $\chi^2(50) = 230.50$, $p < .01$
  - CFI = 0.964
  - RMSEA = 0.050

Multilevel MIMIC Model: Macro Level (1)

- Family Goal
  - % prenatal care
  - % prenatal care 1st trimester
  - mother's education level
  - # child abuse claims
  - # out of home placements
  - % free & reduced lunch
  - % immunized
- Community Goal
  - % accredited primary providers
  - % child care facilities meet standards
  - child care capacity
  - preschool capacity
  - child care costs
  - crime rate
- School Goal
  - student-teacher ratio
  - % all-day kindergarten
  - % teachers w/ early childhood licensure
  - physical environment score
  - instructional environment score
  - social context score
  - % w/ transition plans
  - % permit community building usage



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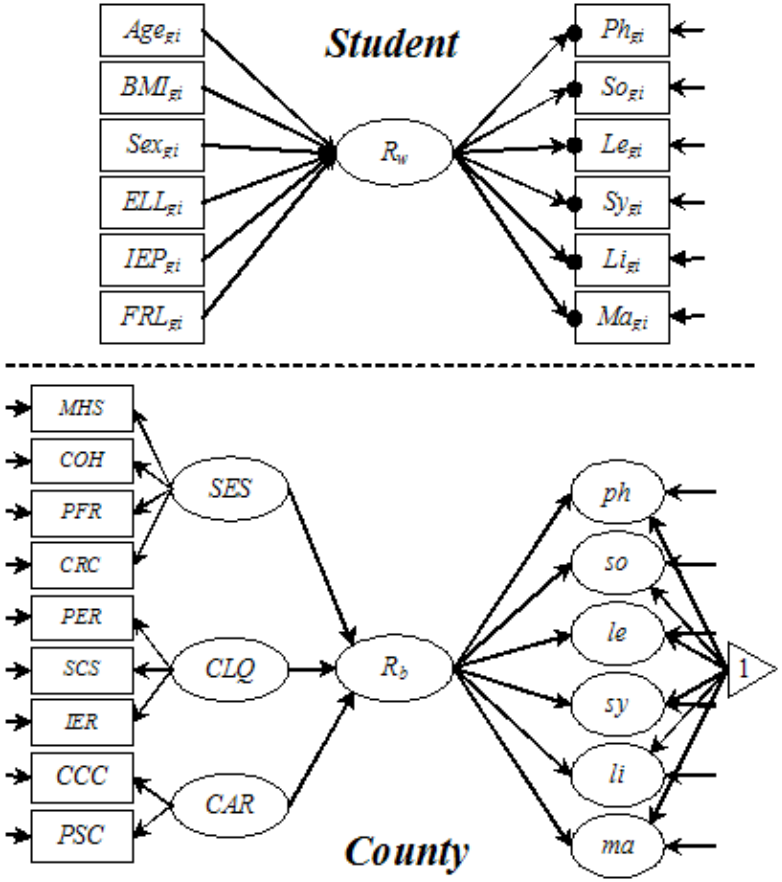
Multilevel MIMIC Model: Macro Level (2)

- Sub-model:
  - ***socio-economic status (SES)*** representing the *family* goal
    - percentage of mother's with at least a high school education (MHS)
    - number of children placed out of home (COH)
    - percentage of kindergarten students on free or reduced lunch (PFR)
    - the crime rate per capita (CRC)
  - ***classroom quality (CLQ)*** representing the *school* goal
    - physical environment rating (PER)
    - social context score (SCS)
    - instructional environment rating (IER)
  - ***child care availability (CAR)*** representing the *community* goal
    - total child care capacity (CCC)
    - total preschool capacity (PSC)



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Some Limiting Conditions?

- Problem(s)
  - Small N - but almost all of the available data
  - Small effects – indirect/proxy effects
- Sampling in MLM
  - possible to obtain proportionally large samples or near-census sampling at the macro-levels
  - especially when sampling from finite geographical locations
- Relevance:
  - educational testing
  - cross-cultural research
  - behavioral ecosystems modeling

- Potential solution??
  - ***finite population correction (fpc)***
    - Down-weighting the standard error proportional to the coverage of the sample to the population

N MAP ACADEMY

Finite Population Correction (fpc)

- Definition
  - Reduces sampling error by decreasing the variance related to the sampling method (sampling without replacement)
  - Adjustment factor varies with the sample size, and is directly related to the proportion of the population sampled
- Usefulness
  - When finite population corrections are omitted, the standard errors are overestimated
  - Standard formulas assume sample taken from a population so large that it may as well be infinite
  - The fpc factors may be used to develop confidence estimates or in sample size estimation

N MAP ACADEMY

Finite Population Correction (fpc)

- Guidelines for applying fpc
  - May be applied to either the variance or the standard error
    - Formula for variance: (N-n) / (N-1)
    - Formula for standard error: √ ((N-n) / (N-1))
  - Proportion of population that may be sampled without application of fpc depends on the research question and the size of effects expected
  - When less than 5% of population has been sampled, fpc factor is negligible
  - Proportion of population for which fpc should be applied is not completely agreed upon – generally 5% - 10%

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Finite Population Corrections:

Primary Model Results

Predictor	Estimate	Standard Errors: Estimated	Standard Errors: Corrected	Confidence Intervals: Original		Confidence Intervals: Corrected		t Ratio (Est./SE): Estimated	t Ratio (Est./SE): Corrected	p values: Estimated	p values: Corrected
F1	0.0001	0.0014	0.0004	-0.0025	0.0028	-0.0007	0.0010	0.11	0.35	p > .05	p > .05
F2	-0.0018	0.0014	0.0004	-0.0046	0.0009	-0.0027	-0.0010	-1.30	-4.20	p > .05	p < .05
F3	0.0027	0.0017	0.0005	-0.0007	0.0061	0.0016	0.0037	1.54	4.98	p > .05	p < .05
F4	-0.0348	0.0207	0.0064	-0.0753	0.0057	-0.0473	-0.0222	-1.68	-5.43	p > .05	p < .05
F5	0.0015	0.0038	0.0012	-0.0059	0.0089	-0.0008	0.0038	0.41	1.31	p > .05	p > .05
F6	-0.0008	0.0016	0.0005	-0.0039	0.0023	-0.0018	0.0002	-0.50	-1.60	p > .05	p > .05
F7	0.0014	0.0017	0.0005	-0.0020	0.0047	0.0003	0.0024	0.79	2.55	p > .05	p < .05
C1	0.0002	0.0004	0.0001	-0.0006	0.0011	0.0000	0.0005	0.56	1.82	p > .05	p > .05
C2	-0.0096	0.0083	0.0026	-0.0259	0.0068	-0.0146	-0.0045	-1.15	-3.70	p > .05	p < .05
C3	-0.0001	0.0006	0.0002	-0.0011	0.0010	-0.0004	0.0003	-0.09	-0.30	p > .05	p > .05
C4	0.0006	0.0022	0.0007	-0.0036	0.0049	-0.0007	0.0019	0.29	0.94	p > .05	p > .05
C5	-0.0017	0.0055	0.0017	-0.0124	0.0091	-0.0050	0.0017	-0.31	-0.99	p > .05	p > .05
C6	0.0031	0.0008	0.0003	0.0015	0.0048	0.0026	0.0037	3.70	11.95	p < .05	p < .05
S1	-0.0145	0.0056	0.0018	-0.0256	-0.0034	-0.0179	-0.0111	-2.56	-8.27	p < .05	p < .05
S2	0.0003	0.0003	0.0001	-0.0003	0.0009	0.0001	0.0005	1.08	3.48	p > .05	p < .05
S3	-0.0008	0.0006	0.0002	-0.0019	0.0003	-0.0012	-0.0005	-1.46	-4.72	p > .05	p < .05
S4	0.0014	0.0049	0.0015	-0.0081	0.0110	-0.0015	0.0044	0.29	0.94	p > .05	p > .05
S5	0.0011	0.0049	0.0015	-0.0085	0.0108	-0.0019	0.0041	0.23	0.74	p > .05	p > .05
S6	-0.0036	0.0049	0.0015	-0.0132	0.0059	-0.0066	-0.0007	-0.75	-2.41	p > .05	p < .05
S7	0.0005	0.0006	0.0002	-0.0007	0.0016	0.0001	0.0008	0.80	2.59	p > .05	p < .05
S8	-0.0527	0.0111	0.0035	-0.0745	-0.0309	-0.0595	-0.0460	-4.74	-15.27	p < .05	p < .05

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Finite Population Corrections:

Sub Model Results

		Standard Errors		Confidence Intervals				t Ratio (Est./SE)		*p* values	
Predictor	Estimate	Estimated	Corrected	Original		Corrected		Estimated	Corrected	Estimated	Corrected
SES	0.0004	0.0022	0.0007	-0.0033	0.0040	-0.0008	0.0015	0.16	0.50	$p > .05$	$p > .05$
CLQ	0.0067	0.0126	0.0039	-0.0140	0.0273	0.0003	0.0131	0.53	1.71	$p > .05$	**$p < .05$**
CAR	-0.0023	0.0056	0.0017	-0.0115	0.0070	-0.0051	0.0006	-0.41	-1.31	$p > .05$	$p > .05$

Using a 1-tailed hypothesis test.

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Finite Population Corrections:

Relevance

- How realistic, or meaningful are finite samples?
  - Very realistic for upper hierarchical levels in education
    - School districts (NCLB), counties (state ed. depts.), states (NAEP/NCLB), countries (PISA)
  - Moderately realistic for cross-cultural studies when assessing culture/country-level variables
  - Potentially realistic for small clinical, under-represented, or geographically isolatable populations

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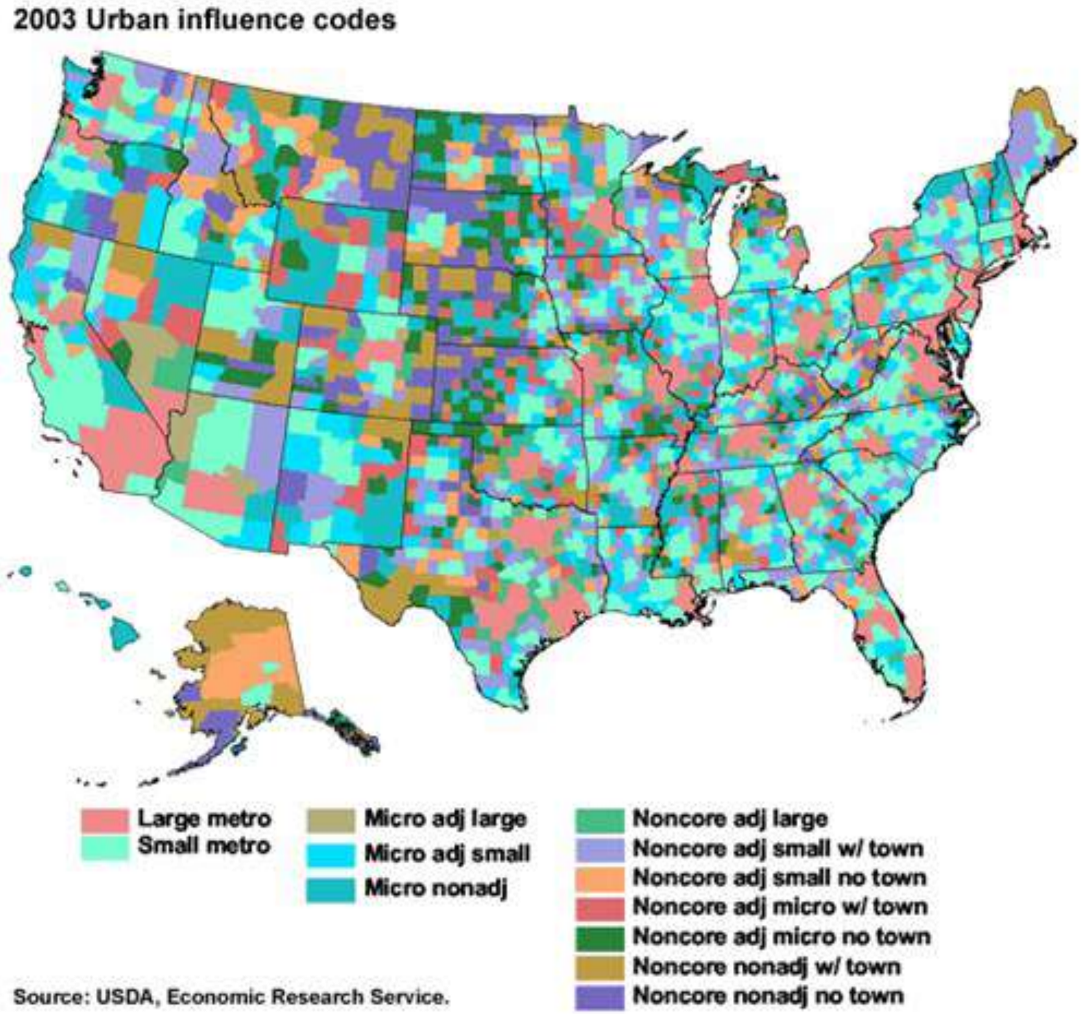
Modeling the Rural Context

University of Nebraska Lincoln

Some Classifications Schemes Can Get Ugly



Defining "What is context?" can get ugly…

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Establishing Organization (Researcher)	Classification	Unit (Level) of Classification	Description
Office of Management & Budget (OMB)	Metropolitan and Micropolitan Statistical Areas	County	METRO: Areas are based on the presence of an urbanized area with a population of at least 50,000. MICRO: Areas are defined as an urban cluster with a population of at least 10,000 but no more than 50,000. Counties that do not fit into either of these definitions are classified as "Outside Core Based Statistical Areas."
United States Census Bureau (Census)	Urban (Urbanized Areas or Urban Clusters) and Rural	Census tract and/or block (county based)	URBAN: Urbanized Areas are defined as having 50,000 or more people and Urban Clusters at least 2,500 and less than 50,000 people. RURAL: Rural areas consist of all territory located outside of urbanized areas and urban clusters, thus populations of fewer than 2,500 residents.
National Center for Education Statistics (NCES)	Urban-Centric Locale Codes	School and school-district	Urban-centric locale codes are based on a combination of proximity to an urbanized area and population size. School districts are classified based on the locale code at which the majority of the district's students are enrolled.
Economic Research Service, United States Department of Agriculture (USDA)	Urban Influence Codes	County	The OMB's metropolitan and micropolitan statistical areas are divided into smaller groups based on population, adjacency to metro areas, and commuting patterns.
Economic Research Service, United States Department of Agriculture (USDA)	Rural-Urban Commuting Area (RUCA)	Census tract and ZIP code	RUCA codes combine measures of population density, urbanization, and commuting patterns at the census tract and ZIP code levels. Coding scheme enables researchers to create both primary and secondary codes for areas.

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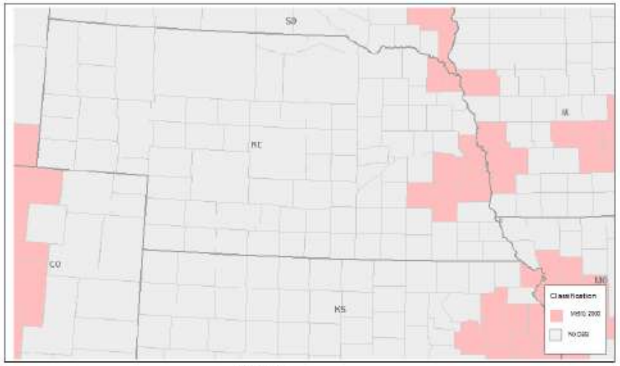
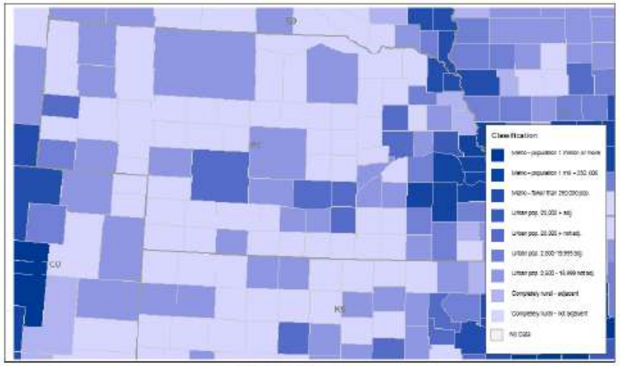
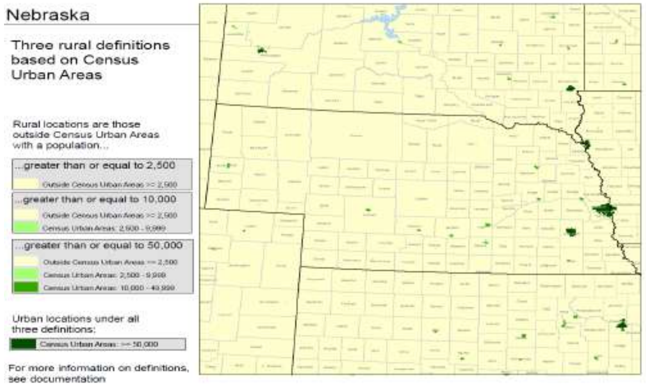
A Look Across Nebraska

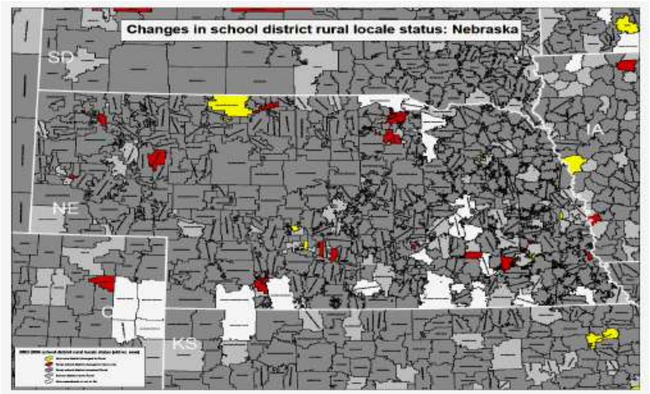


Metro, 2000



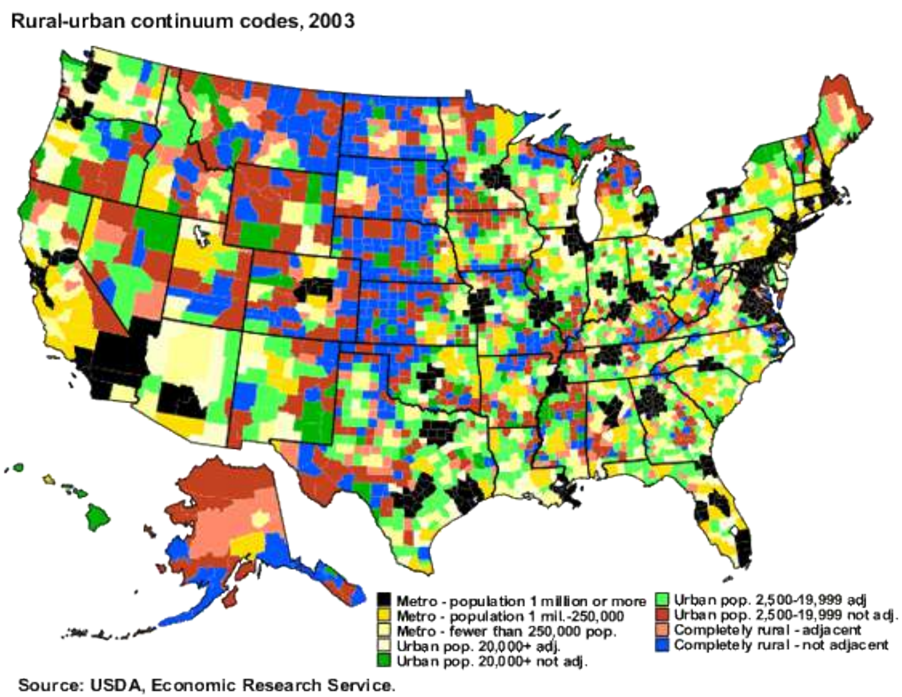
Rural-urban Continuum Code, 2000

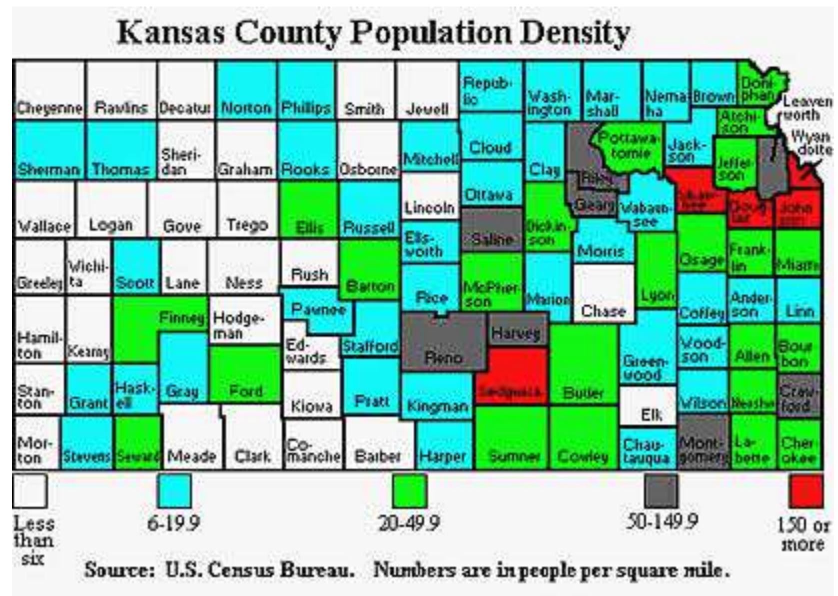




U.S. Population Density by County

Kansas Population Density by County





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How Does the Definition of Rural and its Measurement Impact Inference?

- Measurement
  - Continuous variable
    - Population
    - ***Population per square mile***
  - Categorical variable
    - Johnson Codes
    - Beale RUC Codes
    - ***Other ad hoc categorization (median split)***
  - Other
- Statistical modeling
  - Interaction (continuous or categorical variables)
  - ***Multiple groups SEM***
  - Spatial nesting

	Average # kindergarten (2003)	Average # sampled	Count	% Sampled
Population per Square Mile				
1	32.5	13.5	31	41.5
2	86.5	19.5	38	22.5
3	296.3	23.5	23	7.9
4	552.5	18.1	8	3.3
5	3182.6	30.4	5	1.0
Beale/RUC Codes				
1	1520.5	22.3	6	1.5
2	1766.5	29.0	4	1.6
3	479.3	29.9	7	6.2
4	532.7	28.3	3	5.3
5	493.8	18.3	8	3.7
6	155.5	16.8	11	10.8
7	124.7	19.5	23	15.6
8	60.0	17.5	4	29.2
9	39.3	15.5	39	39.4
Metro/Town/Rural				
1	1149.6	27.0	17	2.3
2	225.0	19.2	45	8.5
3	41.3	15.7	43	38.0

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How Does One Define Rural?

- Previous slide used population per square mile
- USDA Economic Research Service – Rural-Urban Continuum (Beale) Codes
  - Size of a county and its proximity to a metropolitan area
- National Center for Education Statistics – Johnson Codes
  - Proximity to metropolitan areas and on population size and density

2003 Rural-Urban Continuum Codes	
Code	Description
Metro Counties	
1	Counties in metro areas of 1 million population or more
2	Counties in metro areas of 250,000 to 1 million population
3	Counties in metro areas of fewer than 250,000 population
Nonmetro Counties	
4	Urban population of 20,000 or more, adjacent to a metro area
5	Urban population of 20,000 or more, not adjacent to a metro area
6	Urban population of 2,500 to 19,999, adjacent to a metro area
7	Urban population of 2,500 to 19,999, not adjacent to a metro area
8	Completely rural or less than 2,500 urban population, adjacent to a metro area
9	Completely rural or less than 2,500 urban population, not adjacent to a metro area

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How Does One Model Rural as a Moderator?

- Measurement
  - Continuous variable
    - Population
    - ***Population per square mile***
  - Categorical variable
    - Johnson Codes
    - Beale RUC Codes
    - ***Other ad hoc categorization (median split)***
  - Other
- Statistical modeling
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2	225.0	19.2	45	8.5
3	41.3	15.7	43	38.0

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Rurality as a Categorical Moderator

Group RURAL

Number of clusters 59
Average cluster size 19.593

Variable	Intraclass Correlation	Variable	Intraclass Correlation	Variable	Intraclass Correlation
PHYS	**0.041**	**SOC**	**0.094**	**LRN**	**0.067**
SYMB	**0.188**	**LIT**	**0.127**	**MATH**	**0.161**

Group URBAN

Number of clusters 36
Average cluster size 23.278

Variable	Intraclass Correlation	Variable	Intraclass Correlation	Variable	Intraclass Correlation
PHYS	0.003	SOC	0.019	LRN	0.028
SYMB	0.053	LIT	0.028	MATH	0.042

Measurement Invariance: $\chi^2(46) = 89.80$, $p < .01$; RMSEA = 0.031

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Rurality as a Categorical Moderator

- Level 1 MIMIC MODEL [no difference]
  - Constrained Effects
    - $\chi^2(116) = 317.72$, $p < .01$; CFI = 0.964; RMSEA = 0.049
  - Unconstrained Effects
    - $\chi^2(110) = 314.50$, $p < .01$; CFI = 0.963; RMSEA = 0.050

- Level 2 MIMIC MODEL – ***Manifest Variables*** **[Stat. Sig. Difference]**
  - Constrained Effects:
    - $\chi^2(347) = 1021.51$, $p < .01$; CFI = 0.931; RMSEA = 0.052
  - Unconstrained Effects:
    - $\chi^2(326) = 1087.35$, $p < .01$; CFI = 0.922; RMSEA = 0.057

- Level 2 MIMIC MODEL – ***Latent Variables*** [no difference]
  - Constrained Effects
    - $\chi^2(284) = 654.96$, $p < .01$; CFI = 0.948; RMSEA = 0.042
  - Unconstrained Effects
    - $\chi^2(281) = 653.84$, $p < .01$; CFI = 0.948; RMSEA = 0.043

MAP ACADEMY

Rurality as a Categorical Moderator

RURAL				URBAN		
Predictor	Estimate	p-value		Predictor	Estimate	p-value
F1	0.004	0.06		F1A	0.002	0.52
F2	-0.005	0.14		F1B	-0.003	0.09
F3	0.002	0.68		F2A	0.009	0.08
F4	-0.047	0.23		F3A	-0.088	0.29
F5	0.017	**0.00**		F3B	0.000	1.00
F6	-0.004	0.48		F4A	0.003	0.37
F7	0.003	0.55		F5A	0.002	0.74
C1	-0.001	0.13		C1A	-0.002	0.46
C2	-0.007	0.58		C1B	-0.011	0.38
C3	0.001	**0.01**		C2A	-0.002	0.25
C4	-0.002	0.39		C2B	0.003	0.70
C5	-0.007	0.41		C3C	-0.012	0.33
C6	0.003	**0.02**		C4A	0.003	**0.05**
S1	-0.009	0.48		S1A	-0.009	0.58
S2	0.000	0.67		S1C	0.000	0.75
S3	-0.001	0.39		S2A	0.003	**0.04**
S4	-0.007	0.46		S2B	0.015	0.44
S5	0.011	**0.04**		S2C	0.001	0.97
S6	-0.010	0.14		S2D	-0.013	0.52
S7	0.001	0.72		S3A	0.001	0.72
S8	-0.056	**0.00**		S3B	0.009	0.85

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Thank you!

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