**Colloquium Talk Presented in the Centre of Methods and Policy Application in the Social Sciences (COMPASS)**
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# Modeling Ecological and Contextual Effects in the Social Sciences


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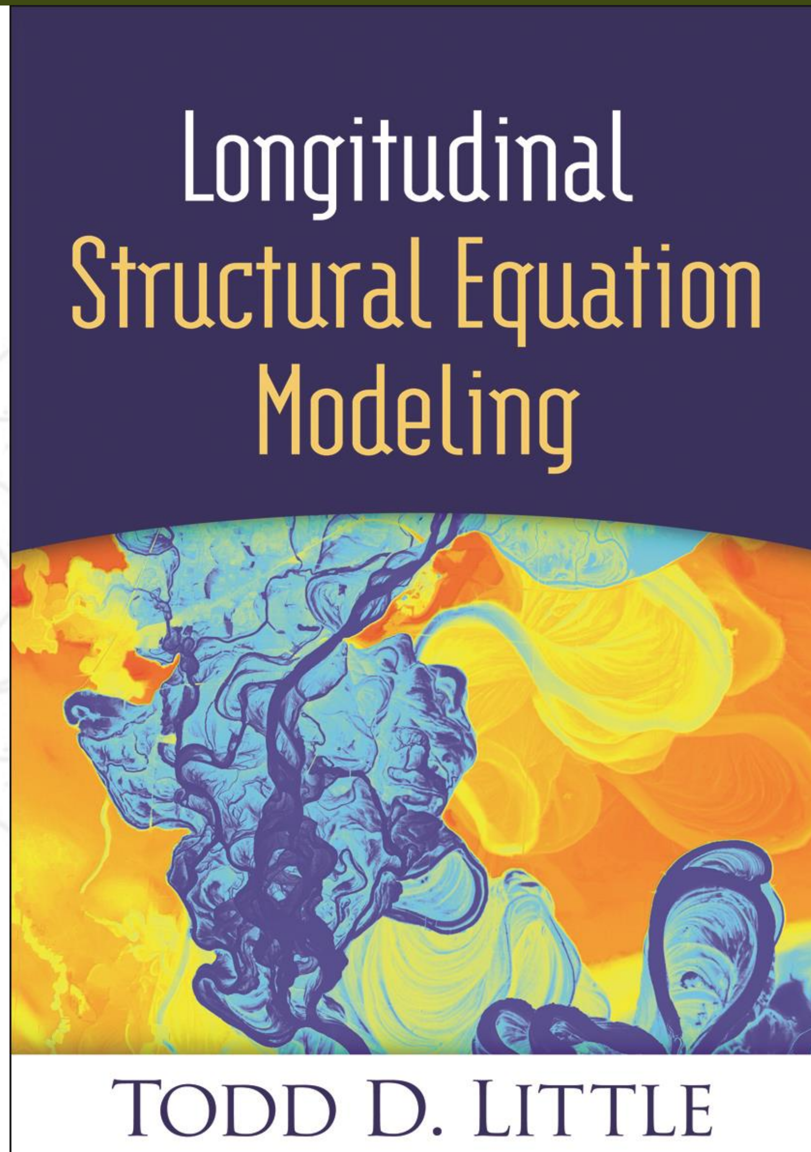
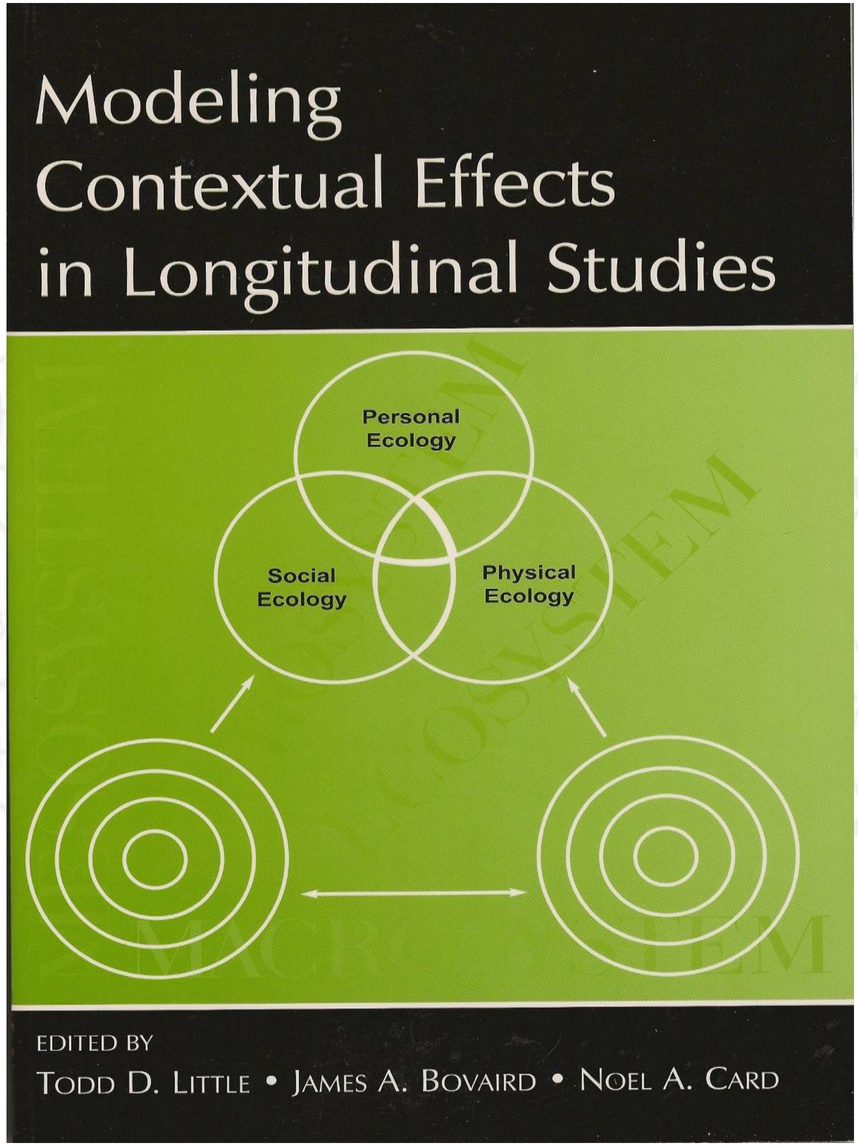

Longitudinal
Structural Equation
Modeling
TODD D. LITTLE

# Context


Modeling
Contextual Effects
in Longitudinal Studies
Personal Ecology
Social Ecology
Physical Ecology
EDITED BY
TODD D. LITTLE • JAMES A. BOVAIRD • NOEL A. CARD

# Context

## The circumstances in which an event occurs; a setting.

- The set of features that influences the performance or the outcome of a process

## The conditions that are relevant to an event, fact, etc.

- From *contextus* a putting together
- From *contexere* to interweave, braid
- circumstances, times, conditions, situation, ambience, frame of reference, background, framework, relation, connection

## Ecology

- The relationship between organisms and their environment.

# Context

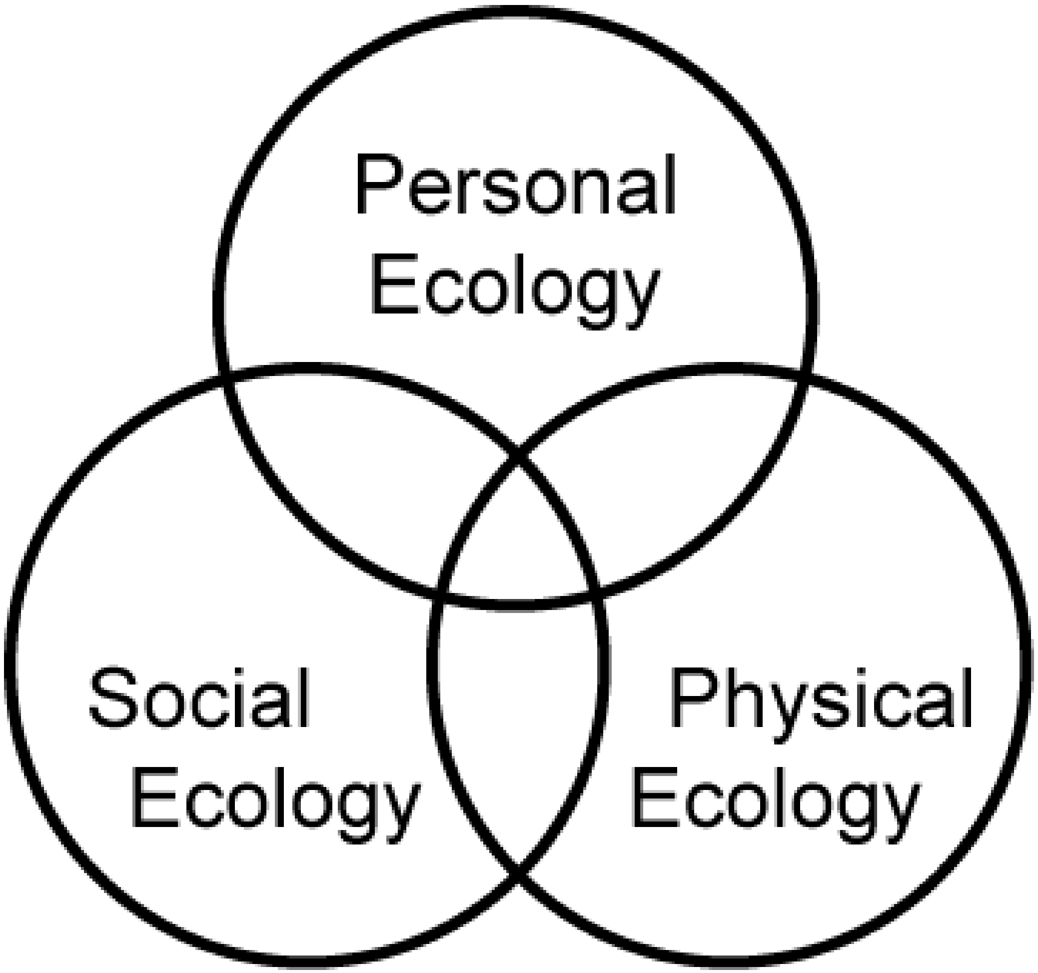



**Figure 2.5**. *Overlapping Ecologies of Human Development*

# Social Ecology

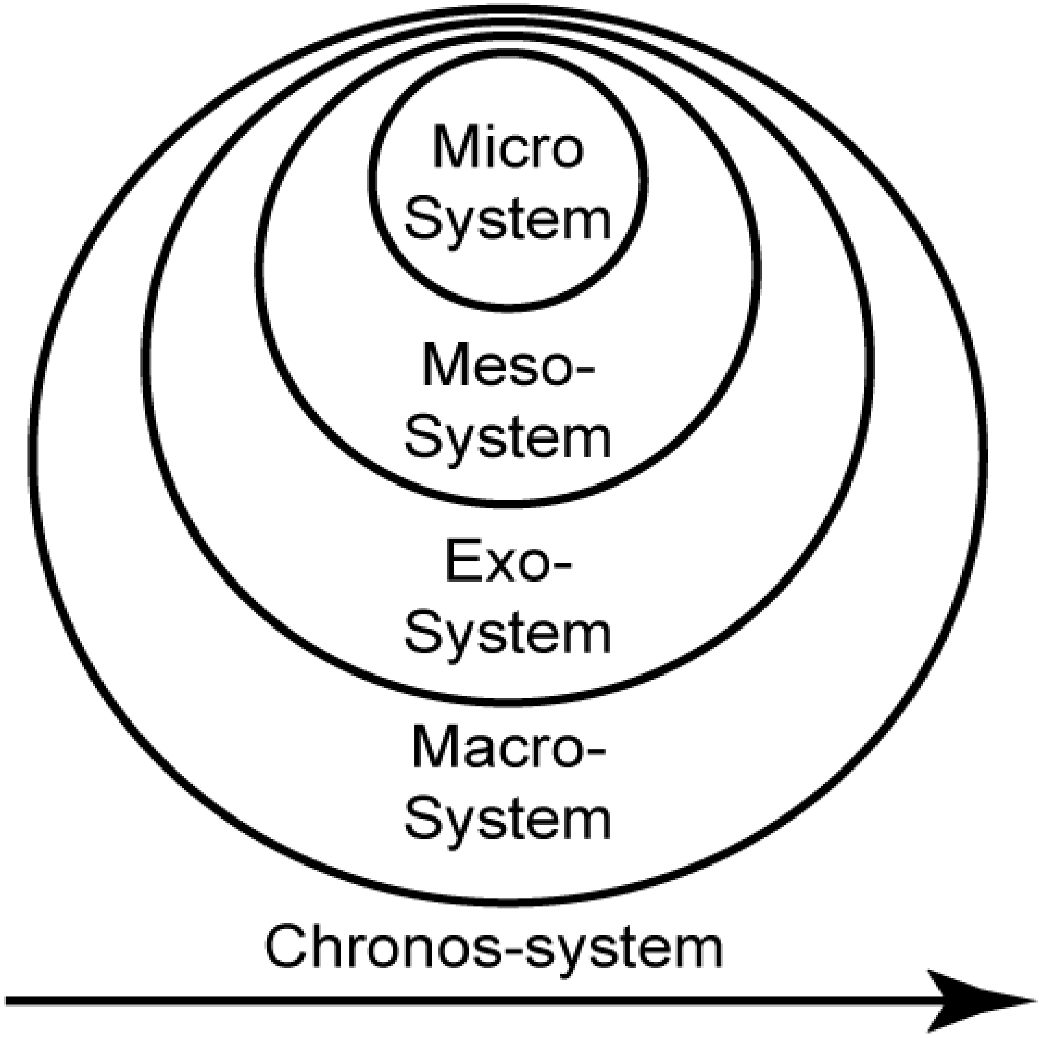



**Figure 2.6**. *Bronfrenbrenner's hierarchy of the Social Ecology*

# Physical Ecology

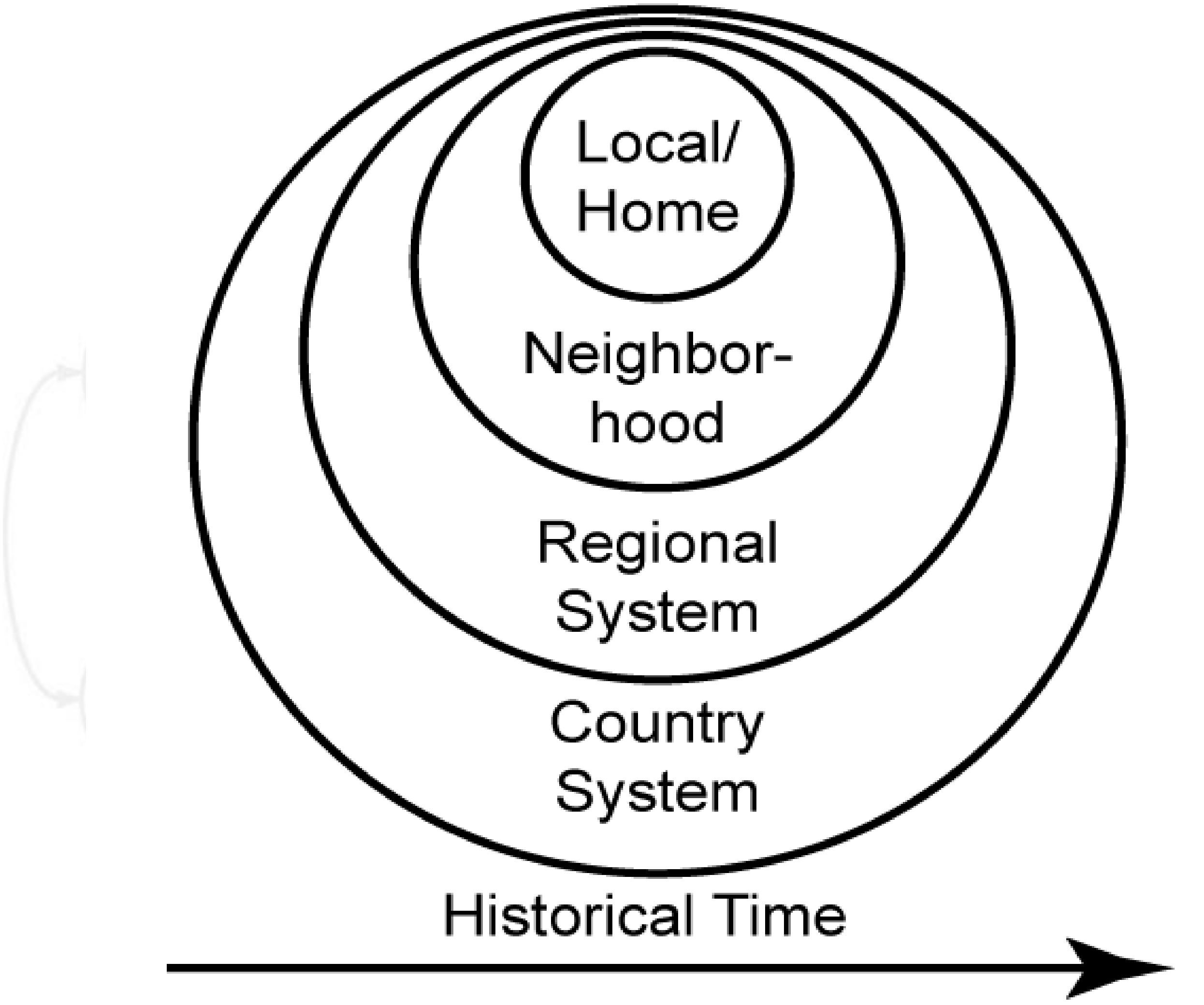



**Figure 2.7**. *Widaman's hierarchy of the Physical Ecology*

# Personal Ecology

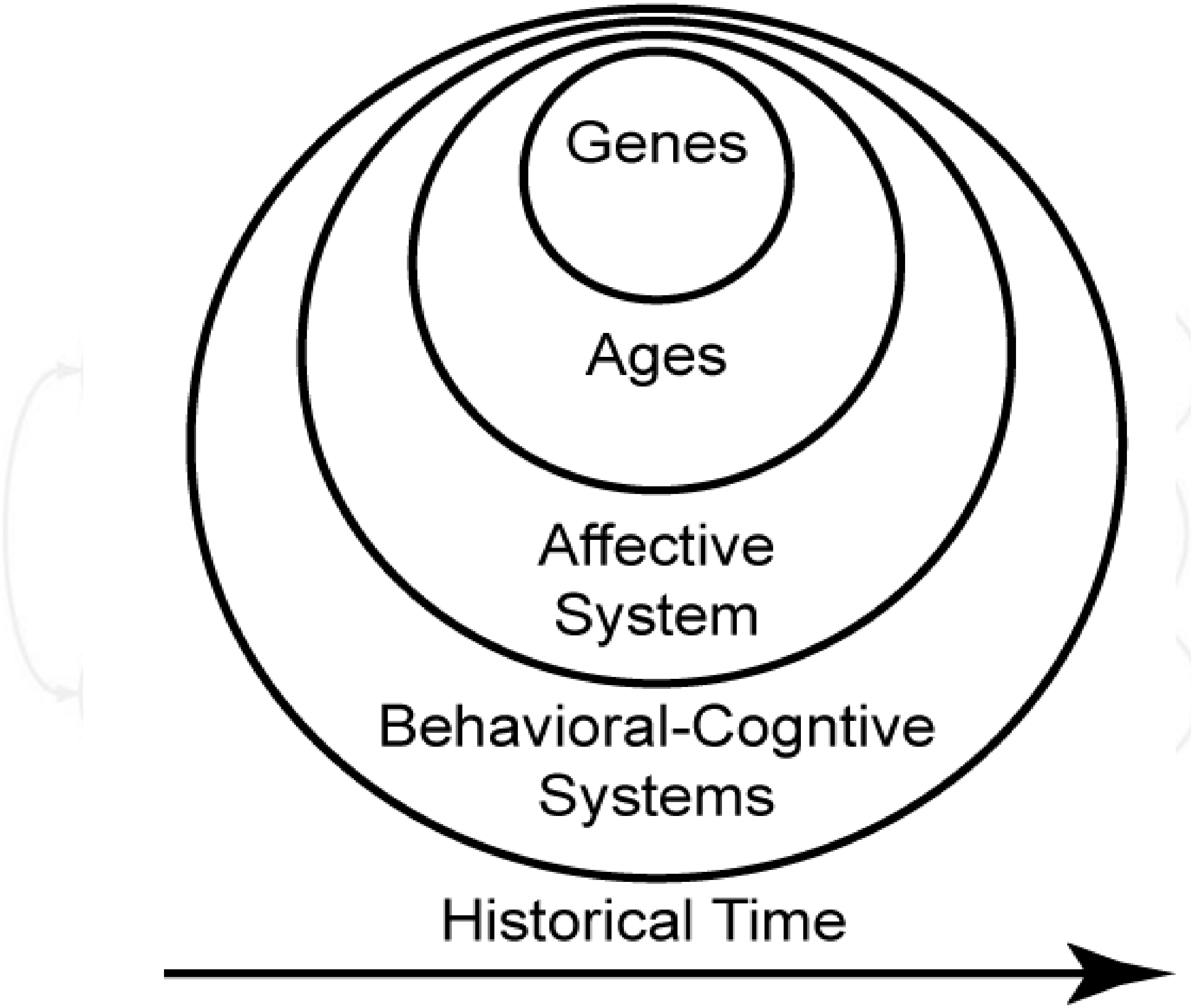



**Figure 2.8**. *Little's hierarchy of the Personal Ecology*

# Contexts as Statistical Relationships

## Direct effects

- Varies at the level of the individual and influences the individual directly

## Indirect (mediated) effects

- *X* varies at the level of the individual and influences the individual through its effect on an intervening variable, M

## Mediating effects

- Distal context influences proximal context which influences the individual

## Moderating effects

- Interactive influences that change the strength of any of the above effects
- Discrete vs. Continuous

## Reciprocal effects and feedback loops

- Cross-time associations that can express as indirect, mediated/mediating, or moderated/moderating.

## Hierarchically nested effects

- Larger units of context that can have direct, indirect, mediating, or moderating effects or be mediated and or moderated.

# Context and Measurement

"Whatever exists at all exists in some amount. To know it thoroughly involves knowing its quantity as well as its quality"

- E. L. Thorndike (1918)

## We should measure persons and contexts well

- **Measures should be appropriate for the construct**
  - ***Contexts should be quantified (borrow from sociology, for example)***
  - ***Developmental measures should address change***
    - **The tragic legacy of test-retest reliability**
- **Measures and analyses should not be haphazard**
  - ***Avoid: "Hey, this new method is cool, let's try it on this data?"***
  - ***Question -> Measurement -> Statistical Model***
  - ***Avoid short forms of existing scales (use intentionally missing design)***
    - **('allure of the bloated specific' idea)**
  - ***Develop or modify to make sure the measurement tool is right***
  - ***Take time to refine and pilot measures (even well-established ones).***

# Context of Measurement

## Homotypic vs. heterotypic expressions across ages

- **e.g., Aggression**

## Surface (proximal) structure vs. deep (ultimate) structure of behavior

- **e.g., helping as resource-directed behavior**

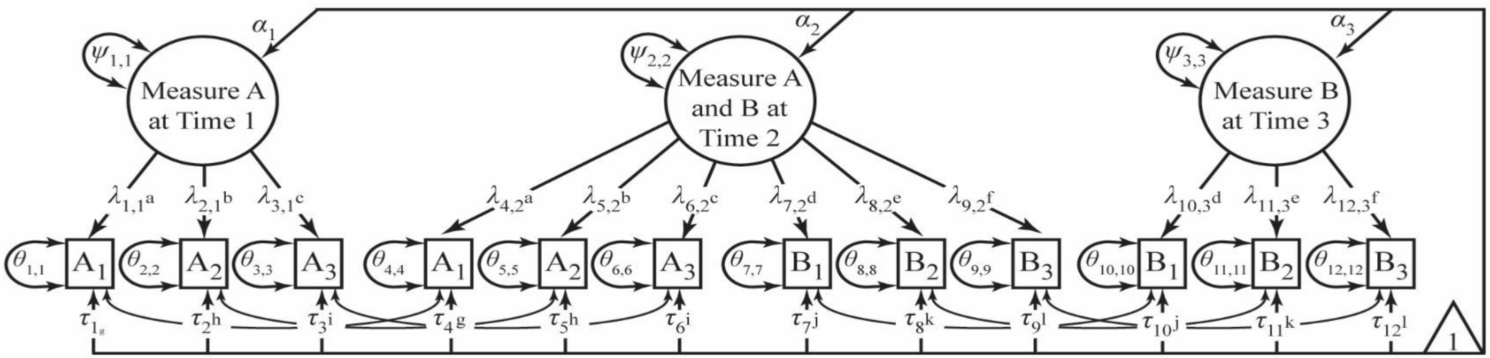
## Typological (subgroups) differences

- **Identification issues and procedures**
  - ***Muthen's m-Plus, Nagin's Proc Traj, Bergman's Sleipner***

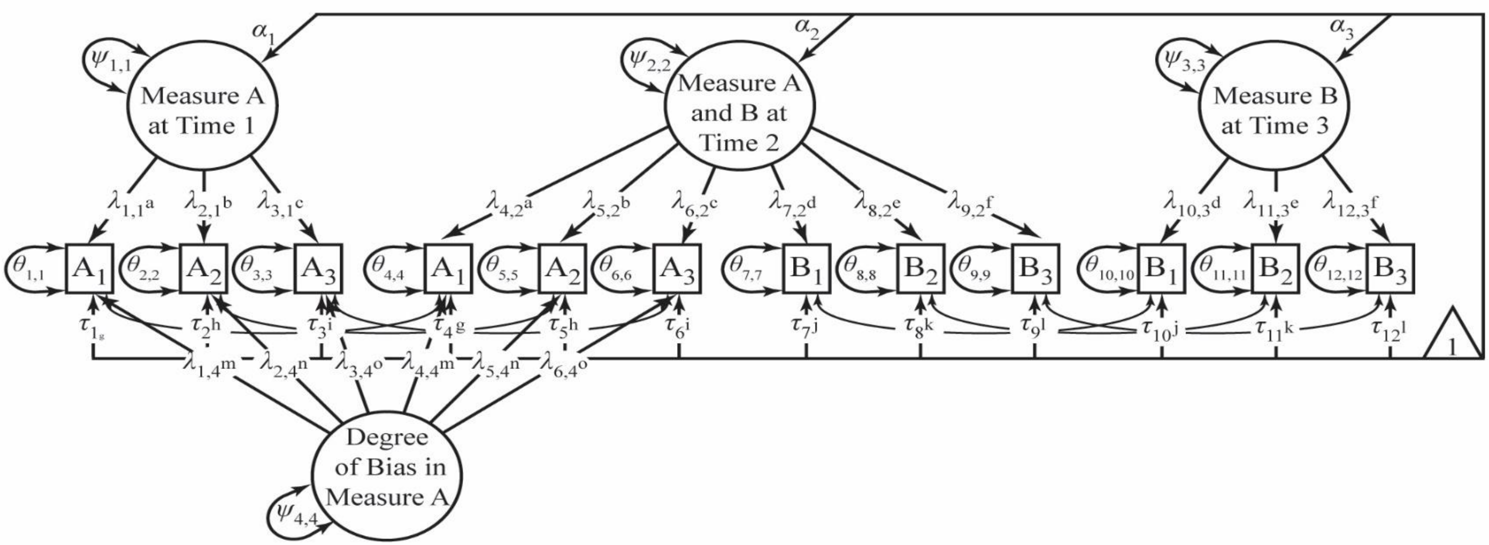
## n-adic (dyadic, triadic, etc.) overlay on all of the various modeling approaches

- **e.g., SRM, APIM, Siena**

A) Establishing comparability of different measures of the same construct over time: No bias




B) Establishing comparability of different measures of the same construct over time: Bias corrected



# Context of Change

## Interindividual differences vs. Intraindividal differences

- Ergodicity conundrum

## Associations (within and between time)

- Covariances and Correlations vs. Regressions
- Direct and Indirect effects
  - *Auto-regressive vs. Cross-lagged*
    - 1st-order vs. higher-order
- Linear vs. non-linear

## Means and Variances

## Mediation vs. Moderation vs. Additive Effects

## $B = f(\text{age})$ vs. $\Delta = f(\text{time})$

# Appropriate Time and Intervals

## Age in years, months, days.

## Experiential time: Amount of time something is experienced

- Years of schooling, length of relationship, amount of practice
- Calibrate on beginning of event, measure time experienced

## Episodic time: Time of onset of a life event

- Toilet trained, driver license, puberty, birth of child, retirement
- Early onset, on-time, late onset: used to classify or calibrate.
- Time since onset or time from normative or expected occurrence.

## Measurement Intervals (rate and span)

- How fast is the developmental process?
- Intervals must be equal to or less than expected processes of change
- Measurement occasions must span the expected period of change
- Cyclical processes
  - *E.g., schooling studies at yearly intervals vs. half-year intervals*

# Transforming to Episodic Time

Data Collection Wave Crossed with Episode Occurance

| Pattern | Wave 1 | Wave 2 | Wave 3 | Wave 4 | Wave 5 | Wave 6 |
|---|---|---|---|---|---|---|
| Pattern 1 | P | P + 1 | P + 2 | P + 3 | P + 4 | P + 5 |
| Pattern 2 | P - 1 | P | P + 1 | P + 2 | P + 3 | P + 4 |
| Pattern 3 | P - 2 | P - 1 | P | P + 1 | P + 2 | P + 3 |
| Pattern 4 | P - 3 | P - 2 | P - 1 | P | P + 1 | P + 2 |
| Pattern 5 | P - 4 | P - 3 | P - 2 | P - 1 | P | P + 1 |
| Pattern 6 | P - 5 | P - 4 | P - 3 | P - 2 | P - 1 | P |

Episodic Occurance Crossed with Data Collection Wave

| | P - 5 | P - 4 | P - 3 | P - 2 | P - 1 | P | P + 1 | P + 2 | P + 3 | P + 4 | P + 5 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pattern 1 | | | | | | W1 | W2 | W3 | W4 | W5 | W6 |
| Pattern 2 | | | | | W1 | W2 | W3 | W4 | W5 | W6 | |
| Pattern 3 | | | | W1 | W2 | W3 | W4 | W5 | W6 | | |
| Pattern 4 | | | W1 | W2 | W3 | W4 | W5 | W6 | | | |
| Pattern 5 | | W1 | W2 | W3 | W4 | W5 | W6 | | | | |
| Pattern 6 | W1 | W2 | W3 | W4 | W5 | W6 | | | | | |

# Transforming to Accelerated Longitudinal

| | Age in years;months for each cohort at each assessment | | | | | |
|---|---|---|---|---|---|---|
| Age/Cohort | 0 Mos | 4 Mos | 8 Mos | 12 Mos | 16 Mos | 20 Mos |
| Age 11 yrs | 11;0 | 11;4 | 11;8 | 12;0 | 12;4 | 12;8 |
| Age 12 yrs | 12;0 | 12;4 | 12;8 | 13;0 | 13;4 | 13;8 |
| Age 13 yrs | 13;0 | 13;4 | 13;8 | 14;0 | 14;4 | 14;8 |
| Age 14 yrs | 14;0 | 14;4 | 14;8 | 15;0 | 15;4 | 15;8 |
| Age 15 yrs | 15;0 | 15;4 | 15;8 | 16;0 | 16;4 | 16;8 |
| Age 16 yrs | 16;0 | 16;4 | 16;8 | 17;0 | 17;4 | 17;8 |

| | Full span of the ages covered | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 11;0 | 11;4 | 11;8 | 12;0 | 12;4 | 12;8 | 13;0 | 13;4 | 13;8 | 14;0 | 14;4 | 14;8 | 15;0 | 15;4 | 15;8 | 16;0 | 16;4 | 16;8 | 17;0 | 17;4 | 17;8 |
| Age 11 yrs | W1 | W2 | W3 | W4 | W5 | W6 | | | | | | | | | | | | | | | |
| Age 12 yrs | | | | W1 | W2 | W3 | W4 | W5 | W6 | | | | | | | | | | | | |
| Age 13 yrs | | | | | | | W1 | W2 | W3 | W4 | W5 | W6 | | | | | | | | | |
| Age 14 yrs | | | | | | | | | | W1 | W2 | W3 | W4 | W5 | W6 | | | | | | |
| Age 15 yrs | | | | | | | | | | | | | W1 | W2 | W3 | W4 | W5 | W6 | | | |
| Age 16 yrs | | | | | | | | | | | | | | | | W1 | W2 | W3 | W4 | W5 | W6 |

# Validity Threats in Longitudinal Work

## Threats to Validity

- **Maturation**
  - *In pre-post experiment effects may be due to maturation not the treatment*
  - *Most longitudinal studies, maturation is the focus.*
- **Regression to the mean**
  - *Only applicable with measurement error*
- **Instrumentation effects (factorial invariance)**
- **Test-retest effects (ugh)**
- **Selection Effects**
  - *Sample Selectivity vs. Selective Attrition*

## Age, Cohort, and Time of Measurement are confounded

- **Sequential designs attempt to unconfound these.**

# The Sequential Designs

| | Cohort (Birth Year) | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Time of Measurement** | | | | | | | | | | | | | | |
| | 1975 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| | 1976 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 |
| Gen-Xers | 1977 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 |
| | 1978 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
| | 1979 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| | 1980 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| | 1981 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 |
| | 1982 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| | 1983 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| | 1984 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
| | 1985 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| | 1986 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| | 1987 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| Gen-Yers | 1988 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
| | 1989 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| | 1990 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |

**Cohort-Sequential**

**Time-Sequential**

**Cross-Sequential**

# Temporal Design

Changes (and causes) take time to Unfold

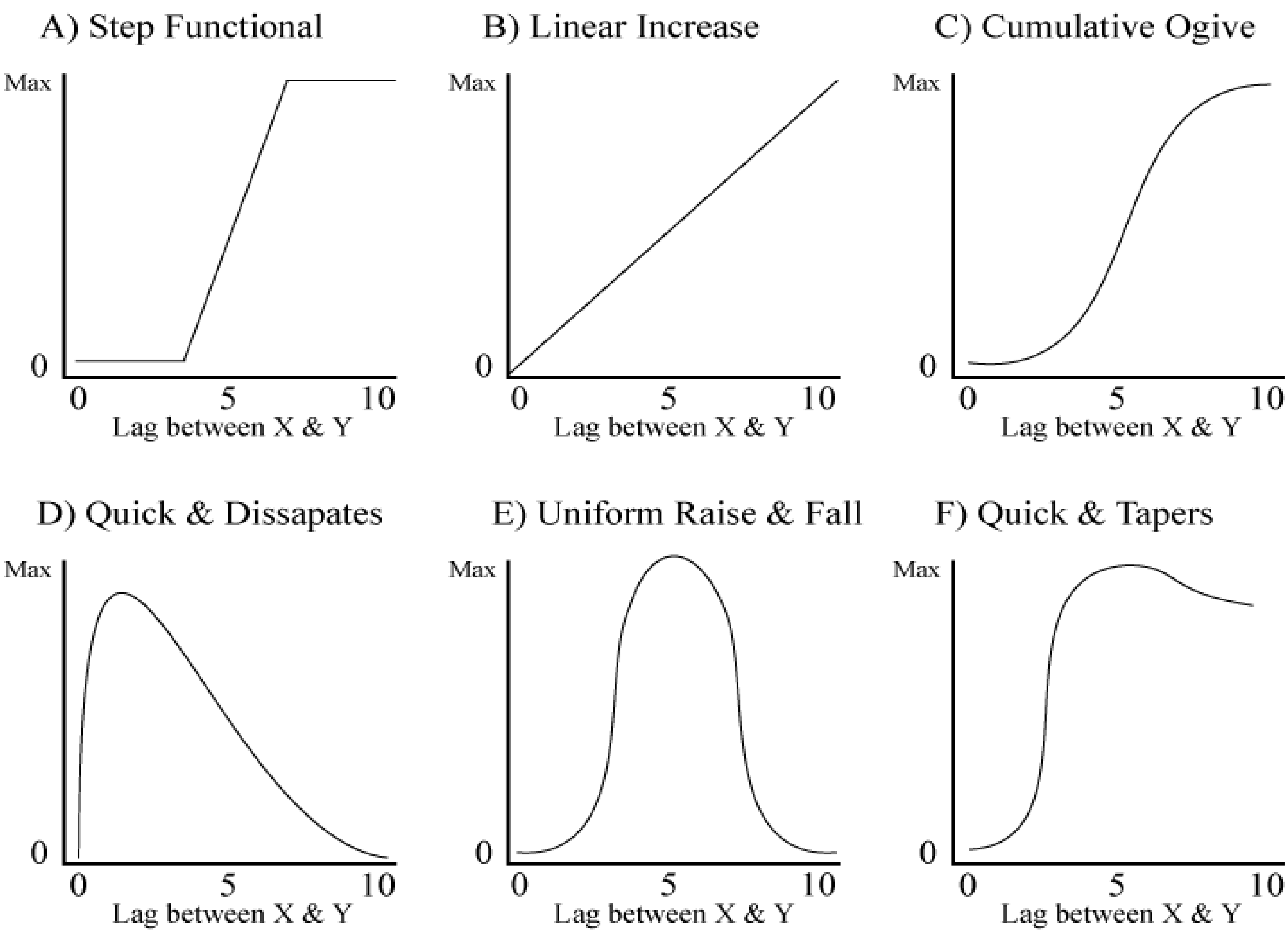
The ability to detect the effect depends on the measurement interval

The ability to model the shape of the effect requires adequate sampling of time intervals.

The ability to model the optimal effect requires knowing the shape in order to pick the optimal (peak) interval.

Lag within Occasion: the Lag as Moderator Model

# Types of Change Effects

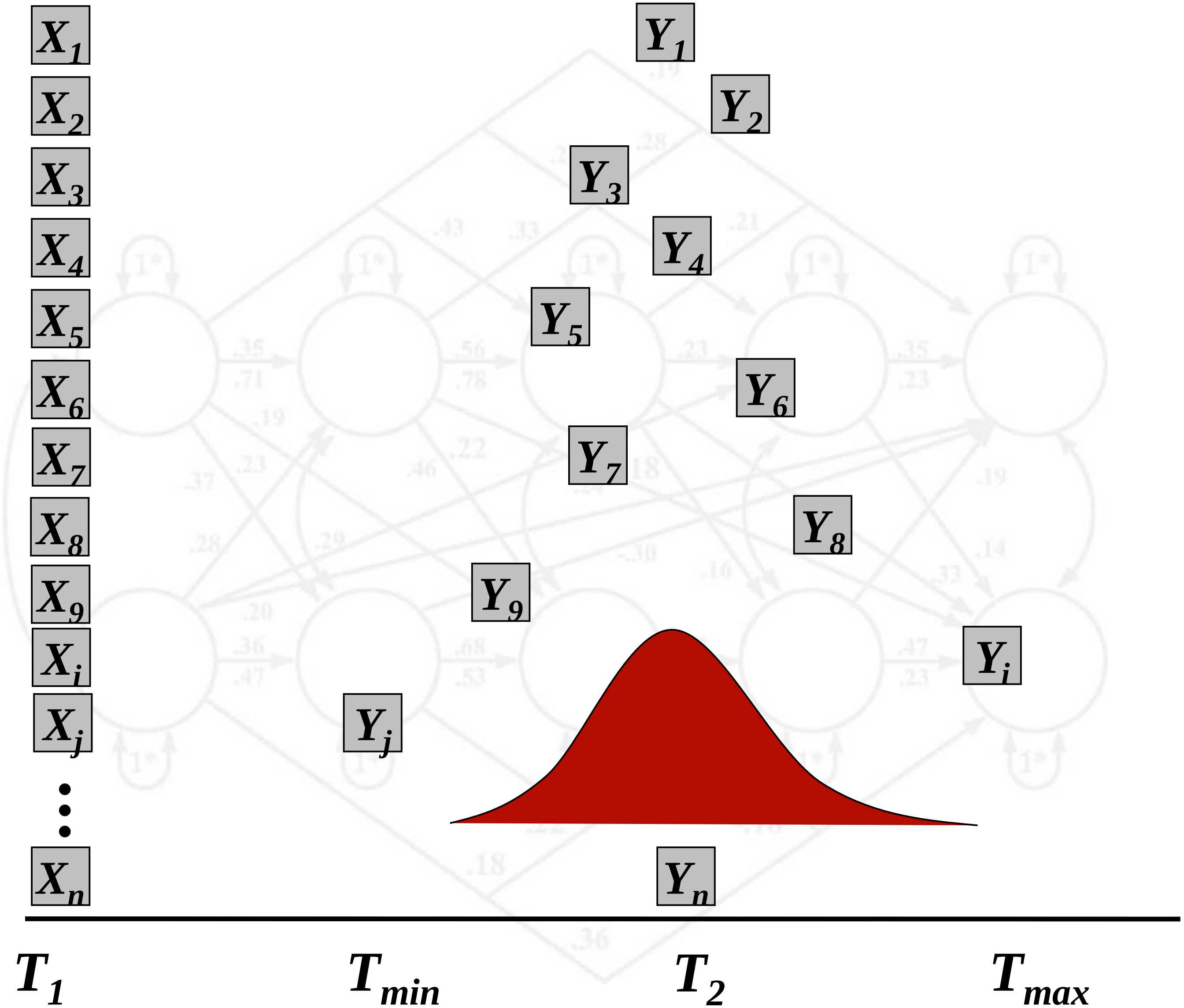


# Lag as Moderator (LAM) Models

One possible way to address the issue of lag choice is to treat lag as a moderator

Following this approach lag is treated as a continuous variable that can vary across individuals

# Variable Actual Assessments



# Multiple Regression LAM model

$$\hat{Y}_i = b_0 + b_1 X_i + b_2 Lag_i + b_3 X_i \times Lag_i$$

**$X_i$ is the focal predictor of outcome $Y_i$**

**$Lag_i$ can vary across persons**

**$b_1$ describes the effect of $X_i$ on $Y_i$ when $Lag_i$ is zero**

**$b_2$ describes the effect of $Lag_i$ on $Y_i$ when $X_i$ is zero**

**$b_3$ describes change in the $X_i \rightarrow Y_i$ relationship as a function of $Lag_i$**

# An Empirical Example

**Data are from the Early Head Start (EHS) Research and Evaluation study ($N$ = 1,823)**

**Data were collected at Time 1 when the focal children were approximately 14 months of age and again at Time 2 when the children were approximately 24 months of age**

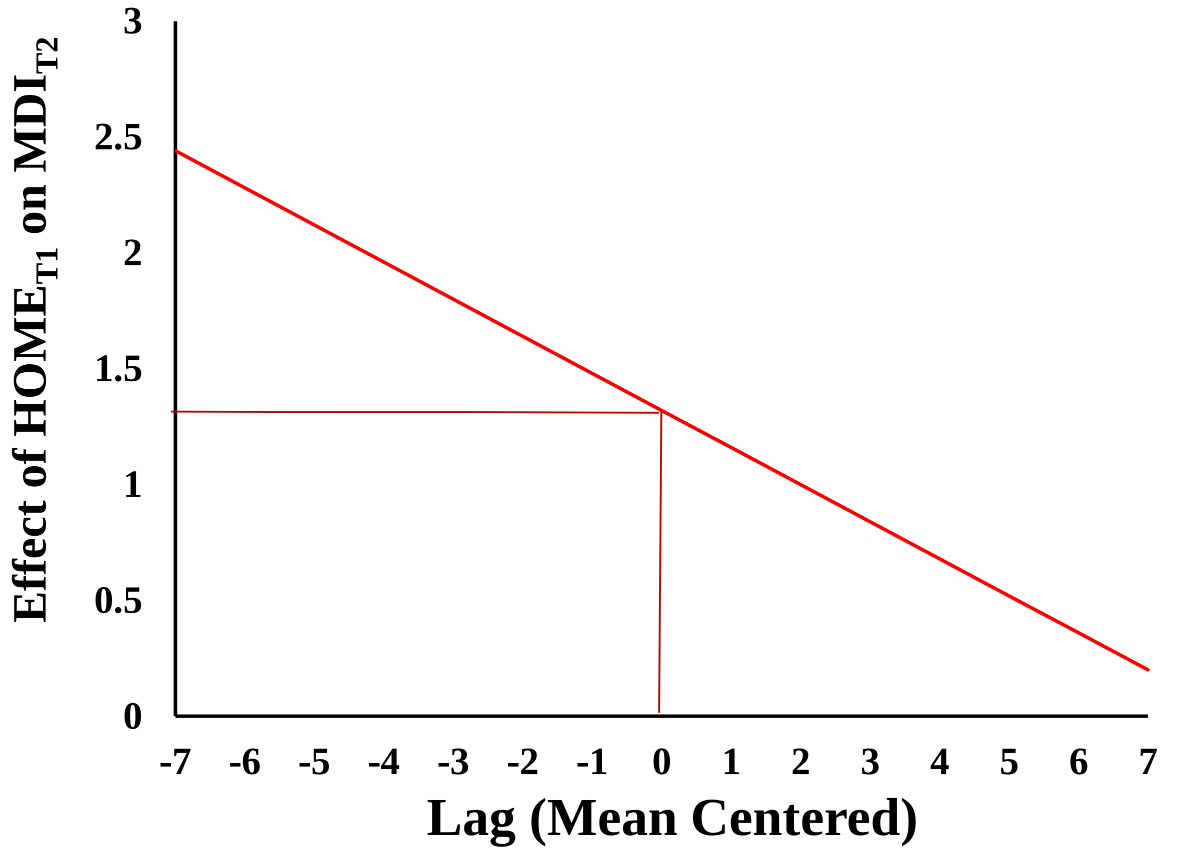
**The average lag between Time 1 and Time 2 observations was 10.3 months with values ranging from 3.0 to 17.3 months**

**Measures:**

- **The Home Observation for the Measurement of the Environment (HOME) assessed the quality of stimulation in the home at Time 1.**
- **The Mental Development Index (MDI) from the Bayley Scales of Infant Development measured developmental status of children at Time 2.**

# HOME predicting MDI

$$MDI_{T2} = b_o + b_1 HOME_{T1} + b_2 Lag + b_3 (HOME_{T1}\ x\ Lag)$$



# Implications of LAM Models

## Lag is embraced

- LAM models allow us to model, not ignore, interactions

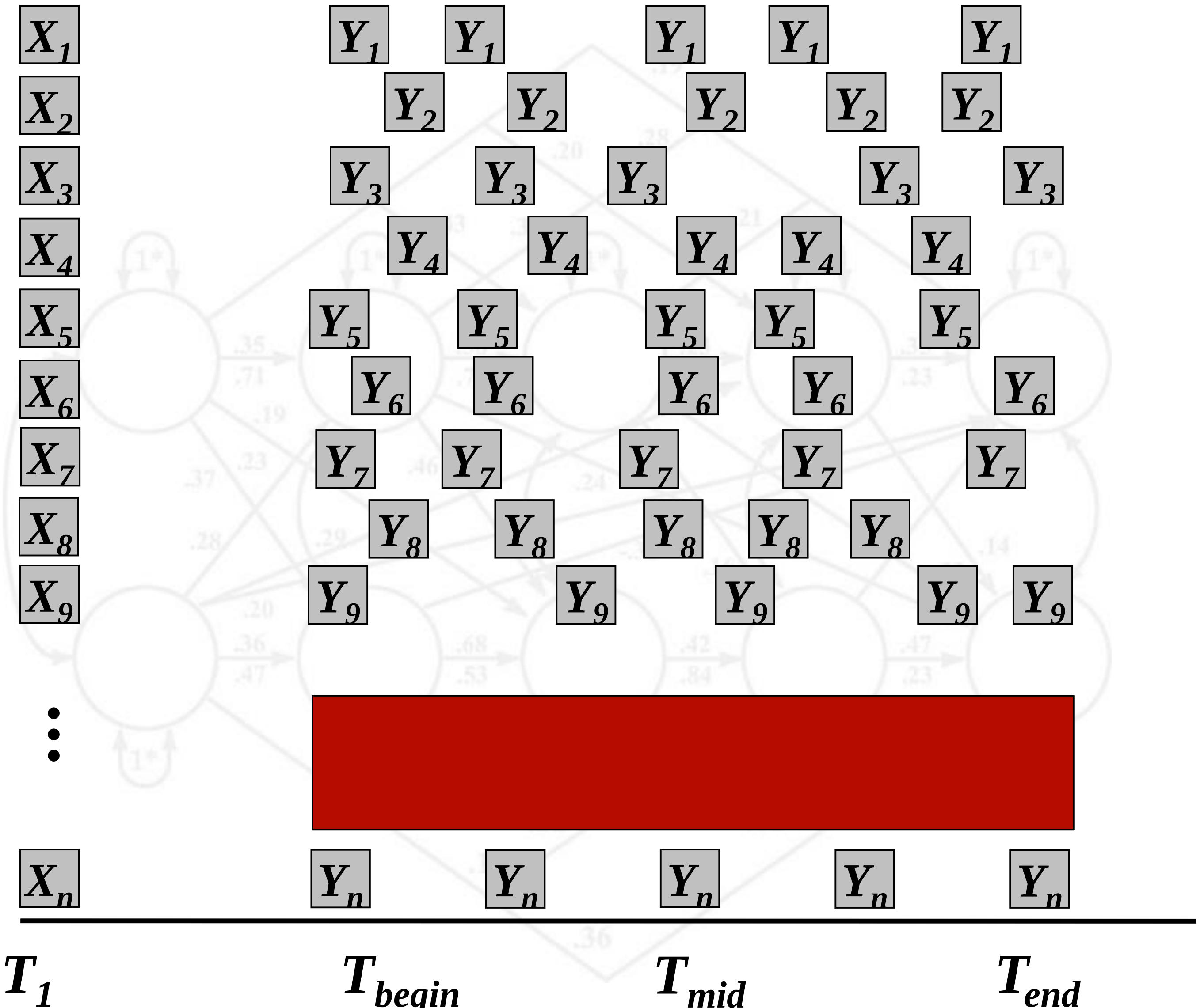
## Selecting Lag is critical

- Sampling only a single lag may limit generalizability

## Theory Building

- LAM models may yield a better understanding of relationships and richer theory regarding those relationships

# Randomly Distributed Assessment



# Multilevel Structures

- **Observations at one level are nested within observations at another and so on.**
- **Number of levels theoretically limitless, bounded by practicality (and software).**
  - **Random sampling at each level.**
- **Multilevel vs. multiple-group structures**
- **Lowest level observations are *not* independent—possible biases in parameter estimates, standard errors, and test of model fit.**
  - **Goal is to model *both* within- and between-cluster relationship.**
- **Examples:**
  - **Students within classrooms**
  - **Times of measurement within persons**

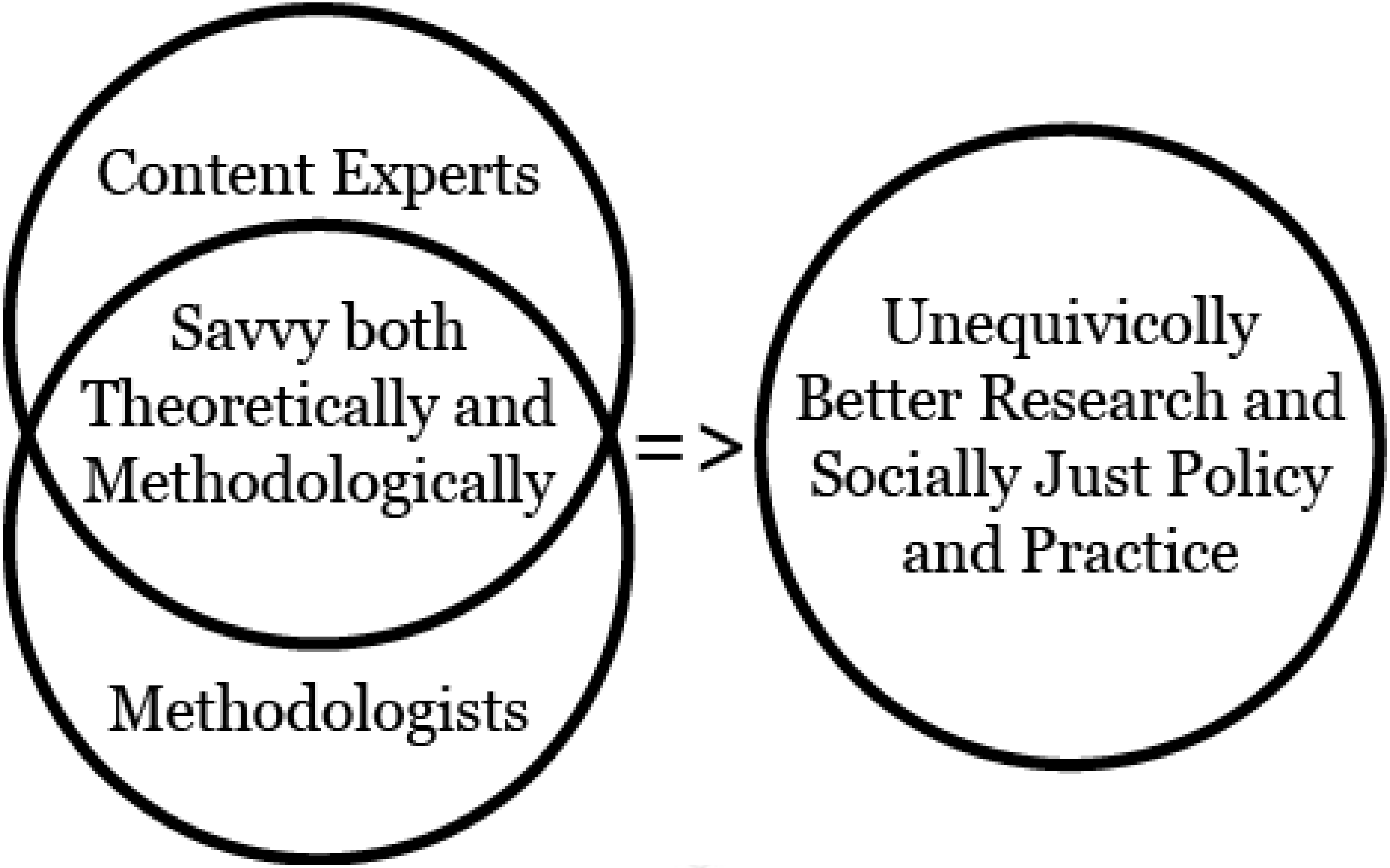
# Modeling Data

- Finding meaning in the massively multivariate world
  - Open system versus closed system
  - Verisimilitude versus Causality
  - Justification and Social Justice
- Optimizing the relations between theory and data
  - Having a dialog between theory and data
    - I am the driver, data are my co-pilot
  - Never let data get in the way of good theory
  - Never let theory get in the way of good data
  - Data are my focus group

# Characteristics of Good Models

| I DO SEEK | DEPICT | LEAP |
|---|---|---|
| **I**ntuition | **D**escribe | **L**ogical and internally consistent |
| **D**esign | **E**xplain | **E**mpirically testable (falsifiable) |
| **O**perationalization | **P**redict | **A**ccounts for extant findings |
| **S**pecification | **I**mprove | **P**arsimonious (sufficient verisimilitude) |
| **E**stimation | **C**hange | |
| **E**valuation | **T**est | |
| **K**ommensuration | | |

# Wesearch Instead of Mesearch



# The Ubiquity of Errors

ERROR, ERROR
IN MY MODEL,
WHO'S THE
FAIREST OF
THEM ALL?

# GIGO, FUDSI, P-Hacking, Harking, Larking, >50 Shades of Grey, SOL

Error Types I, II, III, IV, S, M … ?

Data → Model → Output

Design Error

Purpose Error

Reviewer Error

Commission Errors
Omission Errors

Measurement Practice Error

Missing Data Model Error

Nepotism Error

Special Interest Error

L.O.V.E.

Sampling Error

Parsimony Error

Quixotic Empiricism Error

Mesearch Error

Psuedo-Hobbsian Rsearcher Error

Mesearch Error

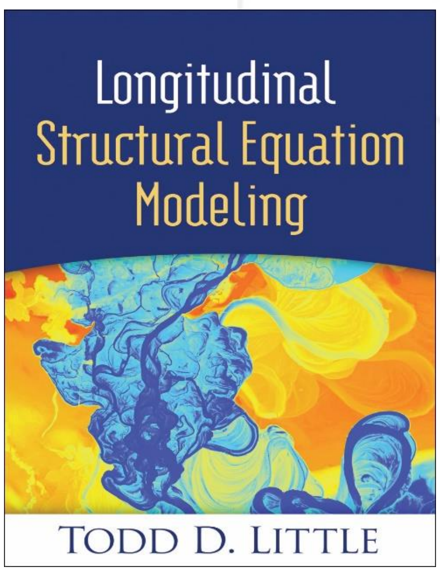
Massively Multivariate World

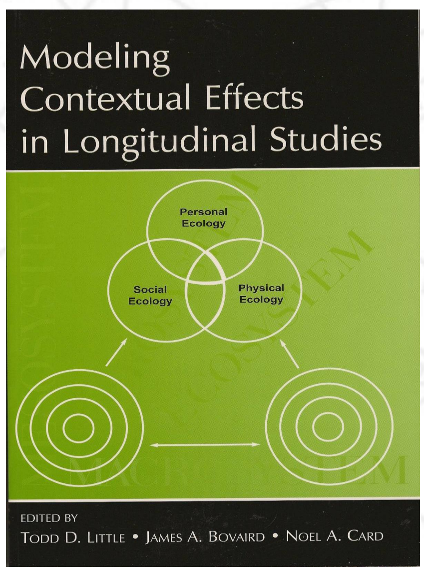
Mesearch Error

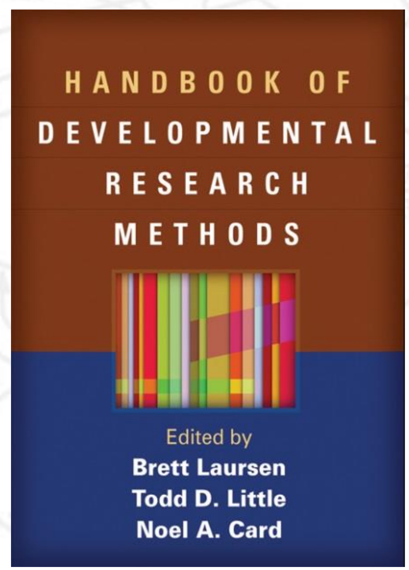
Little, Widaman, Levy, Rodgers & Hancock, in press

# Design and Measurement Issues

- Not all "advances" in developmental research are analysis based: we need to (re)start with the basics!
- The Ubiquity of Error
- Measurement, Measurement, Measurement
- My sources, each of which highlights design and measurement:




# (re) focus on Measurement

- **Rethink Likert scales**
  - ***Our great-great-great-great academic progenitors used them!***
- **Take advantage of touch screen technology and software**
  - ***Using "rulers" and "sliders" is now easy and efficient***
- **Develop measures/procedures that are sensitive to change**
  - ***Retrospective Pretest Posttest Design***
  - ***Direct change Assessmemt***

**"Whatever exists at all exists in some amount. To know it thoroughly involves knowing its quantity as well as its quality"**

**- E. L. Thorndike (1918)**

# Retrospective Pre-post Design

*I am curious about science.*

**Strongly Disagree**

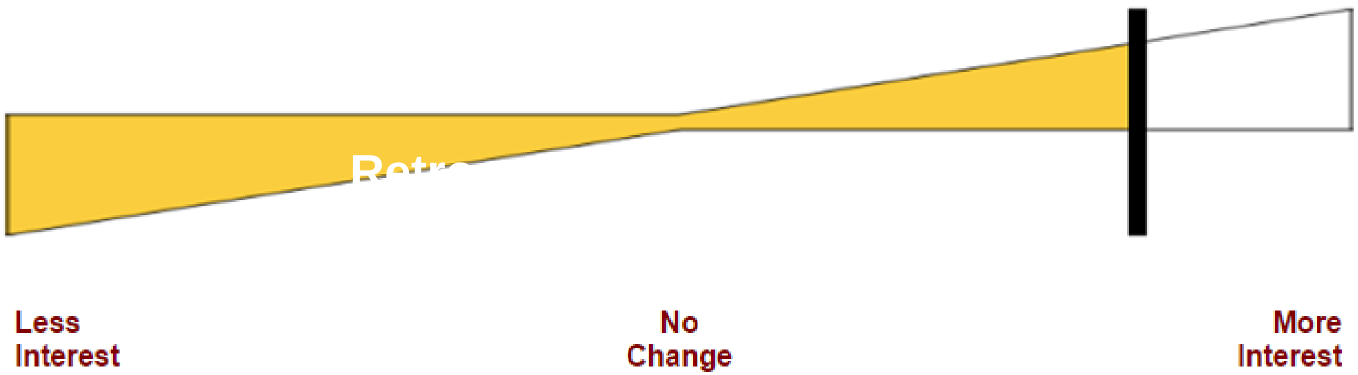
**Strongly Agree**

**Before the program**

**At this time**

# Visual Analog Scaling

*I am curious about technology.*




*Preview Link – Qualtrics*

# Recommended readings

**Little, T.D. (2013). Longitudinal Structural Equation Modeling. New York, NY: Guilford Press**

- **Duh.**

**Card, N. A., & Little, T. D. (2007). Longitudinal modeling of developmental processes. *International Journal of Behavioral Development, 31, 297-302***

- **Introduction to special issue, but first part identifies basic issues in longitudinal modeling and then points you to the innovations covered in the special issue.**

**Little, T. D., Card, N. A., Preacher, K. J., & McConnell, E. (2009). Modeling longitudinal data from research on adolescence. In R. Lerner & L. Steinberg (Eds.)., Handbook of Adolescent Psychology (4th Ed., pp 15-54). Wiley.**

- **Provides a broad summary of the three classes of techniques**

**Card, N. A., Little, T. D., & Bovaird, J. A. (2007). Modeling ecological and contextual effects in longitudinal studies of human development. In T. D. Little, J. A., Bovaird, & N. A. Card (Eds.), *Modeling contextual effects in longitudinal studies* (pp. 1-11). Mahwah, NJ: LEA**

- **Introduction to our book that points you to a lot of really great chapters covering many of these issues in detail**

# Recommended readings


Little, T. D., Widaman, K. F., Levy, R., Rodgers, J. L., & Handcock, G. R. (in press). Error, error, in my model, who's the fairest of them all. *Research on Human Development.*

Little, T. D., Gorrall, B. K., Panko, P. & Jacob D. Curtis, J. D. (in press). Modern practices to improve human developmental research. *Research on Human Development.*

Little, T. D. (2017). Methodological considerations for research on ethnopolitical violence. *Development and Psychopathology*, *29*, 71-77.

Little, T. D. (2015). Methodological practice as matters of justice, justification, and the pursuit of verisimilitude. *Research in Human Development*, *12*, 268-273.