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METHODOLOGY, ANALYTICS & PSYCHOMETRICS

Measuring Dyadic Relationships: Introduction to Dyadic Indices and Approaches

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Nebraska Methodology Application Series

April 16, 2021

University of Nebraska Lincoln

Overview

- Foundations
  - Nonindependence
  - Distinguishability
  - Matched Pairs Research Designs

- Methods For Measuring Dyad-Level Indices
  - Composite Variable Approaches
    - E.g., Intraclass Correlation
  - Latent Modeling Approaches
    - Congruence/Difference Models
    - Actor-Partner Interdependence Model – *k* index

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FOUNDATIONS

~Definitions and Why They Are Feared~

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Theoretical Frameworks

- Scholars interested in close relationship dynamics have long recognized the complexity and interdependent nature of these processes
  - e.g., married/partnered individuals, parent-child, siblings, parent-teacher

- Theory highlights interdependency and the examination of ***both*** dyad members' perspectives, experiences, characteristics in capturing the complexity of relationships
  - Social Ecology Model
  - Ecological Systems
  - Family Systems Theory

Bronfenbrenner, 1979; Cox & Paley, 2003
Hinde, 1979
Huston, 2000

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Dyadic Data

"The intrinsically dyadic nature of many of the measurements in social and behavioral science research means that they are often linked to other measurements in the study, and the strengths of these links may be one of the most important research questions to be examined"

~Kenny, Kashy, & Cook, 2006, p. 2

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Examples

- Both members rate how satisfied they are or the quality of the relationship
  - Parent-teacher; older-younger siblings; spouses/partners; parent-child

- Two persons in a relationship are asked to respond about their own behavior

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Similarity

- Individual and Relational Functioning
  - Related not only to the individuals themselves, but also to complex systems of behaviors between individuals

- Similarity
  - One important representation of the complex system of behaviors between system members

- Family Systems Theory Example
  - Individuals within the same family system may share a common perception of the world, impacting interactions within family relationships (Reiss, 1981, as cited in Deal, Wampler, & Halverson, 1992)
  - Assessments of similarity allow us to test this theoretical assumption

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Using Dyadic Indices in Research

- Understand how similar, or dissimilar, dyad members are to one another

- Use similarity (or dissimilarity) scores to predict other variables, or use other variables to predict levels of similarity
  - Can use manifest or latent variable approaches

- Can test hypotheses about constructs
  - Complementarity
  - The influence of shared environment on dyad member similarity
  - The influence of shared views on relationship quality
  - The pattern of mutual vs. individual influence in a relational context

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NONINDEPENDENCE

Interdependence

“When we collect data in which the sample units do not arrive one at a time, as in the idealized word of independence, but instead arrive two at a time, as in the real world of dyadic interdependence, we are faced with a frustrating dilemma… Interdependence in one’s data is typically viewed as a nuisance and so dyadic researchers have developed strategies to sweep interdependence under the statistical rug ”

~Gonzalez & Griffin, 1997

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Nonindependence

"If the two scores from the two members of the dyad are nonindependent, then those two scores are more similar to (or different from) one another than are two scores from two people who are not members of the same dyad"

~(KKC, p. 4, 2006)

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Mechanisms of Dyadic Data Nonindependence

- Voluntary Linkage
  - Friends; dating partners; parents, students, and teachers
- Kinship Linkage
  - Family members
- Experimental Linkage
  - Created in a study/laboratory
- Yoked Linkage
  - No personal interactions, but exposure to same environmental stimuli

Kenny, Kashy, & Cook, 2006

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Processes Producing Nonindependence

- Partner Effect
  - Characteristic or behavior of one individual relates to partner's outcomes
- Mutual Influence
  - Both individuals' outcomes directly affect one another
- Common Fate
  - Both individuals are exposed to the same causal factors

Kenny, Kashy, & Cook, 2006

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Errors to Avoid

1) Assumed independence error
   - Treat all observations as independent observations

2) Deletion error
   - Not using half of the sample

3) Cross-level error
   - Using dyad means on each variable

4) Levels of analysis error
   - Interpreting correlations of dyad means as “dyad-level processes”
   - Interpreting correlations of individual observations as “individual-level processes”

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DISTINGUISHABILITY

Dyad Member Distinguishability

- Distinguishable Dyads
  - Husbands and Wives distinguished by gender
  - Older and Younger Siblings distinguished by birth order
  - Mothers and Daughters distinguished by family role
  - Teacher and Parent distinguished by role
  - First and second author distinguished by authorship order

- Nondistinguishable Dyads
  - “Exchangeable Dyads”
  - Same gender couples, colleagues, roommates
  - Monozygotic twins

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Theoretical and Empirical Distinguishability

- Distinguishability is both *theoretical* and *empirical*
  - It is advisable to choose the distinction that is most theoretically meaningful for the current research and questions under study
  - Do the scores differ in nature?
    - Test empirically if dyad members are distinguishable!
    - Means
    - Variance
    - Factor loadings, etc.

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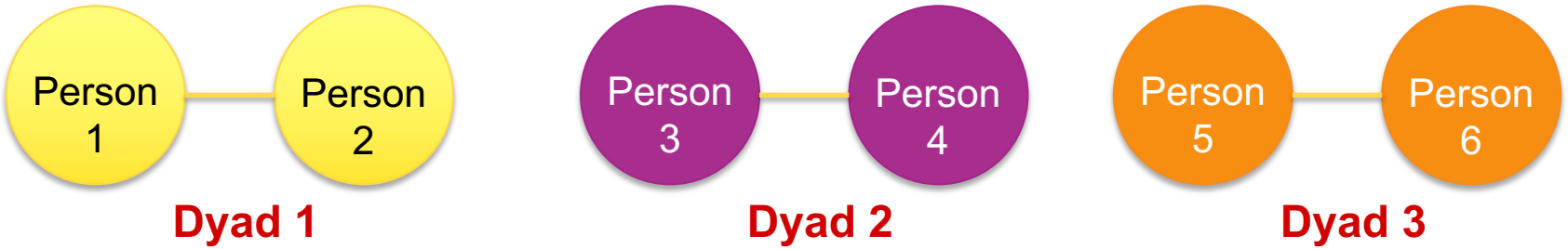
MATCHED PAIRS DYADIC DESIGN

Data Collection

- Standard design; 75% of dyadic research

- Responses collected from both members of a dyad
  - Each person is a member of only one dyad
  - *n* = dyads, 2*n* = individuals; 2*n* observations per variable
  - E.g., 150 parent-teacher dyads; 150 teachers and 150 parents = 300 participants (reporters)

- Reciprocal reporting
  - Provides utility in capturing interpersonal processes
  - E.g., relationship satisfaction, quality



Kashy & Levesque, 2000

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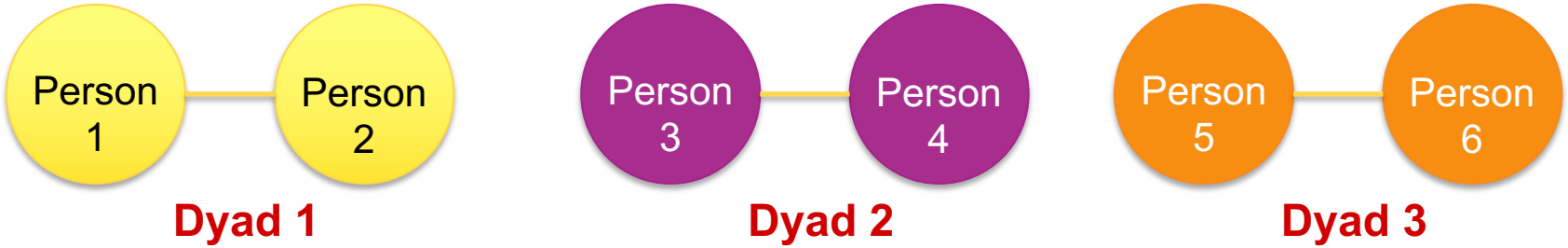
Analytic Approach

- To capture inherent interdependence - poses unique analytic challenges

- Necessitates the dyad as unit of analysis and not the individual
  - *N* = dyads
  - Because members of a dyad interact, there are really only N (dyads) pieces of independent information



Kashy & Levesque, 2000

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MEASURING DYAD-LEVEL INDICES

Dyadic Indices

- Quantitative measures of nonindependence

- Composite Variable Approaches
  - Dissimilarity
  - Similarity

- Latent Variable Modeling Approaches
  - Difference / congruence (agreement, fit, similarity) models
  - Dyadic patterns of interdependence

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Manifest Composite Variable Approaches

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Dyadic Indices: Dissimilarity

- Measures of Dissimilarity
  - Discrepancy: ∑ absolute difference / number of measures
  - d^2 : ∑ squared difference between measures
  - Distance: Square root of d^2; higher scores indicate less congruence

- Allow consideration of multiple aspects of agreement
  - Agreement in the average level, shape or pattern, and spread of the item responses

Kenny, Kashy, & Cook (2006)

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Dyadic Indices: Similarity

- Measures of Similarity
  - Allow for the consideration of agreement or relative similarity of dyad members
  - Correlation and Covariance of measures
  - Intraclass correlation
    - Stereotype-adjusted Intraclass correlation

Kenny, Kashy, & Cook (2006)

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Measures of Similarity

- Can be positive
  - Relative similarity of dyad members

- Can be negative
  - Dyad members are relatively different from one another
  - Compensation
    - One person is overly friendly, the other person reacts by distancing
  - Social Comparison
    - Satisfaction after a tennis match is determined by who won or lost

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Kenny, Kashy, & Cook, 2006

Correlation Coefficient

- A simple correlation measures how dyad members' scores on a given measure increase and decrease
  - Measures the correspondence between relative rank orderings
  - This says nothing about the actual level or spread of responses
  - On a given measure a wife could have scores of 1 and 2 and a husband could have scores of 4 and 5, yet their responses could be *perfectly* correlated

- Correlation—or shared variance—does *not* tell the researcher anything about similarity of dyad members' absolute scores

Deal, Wampler, & Halverson (1992)

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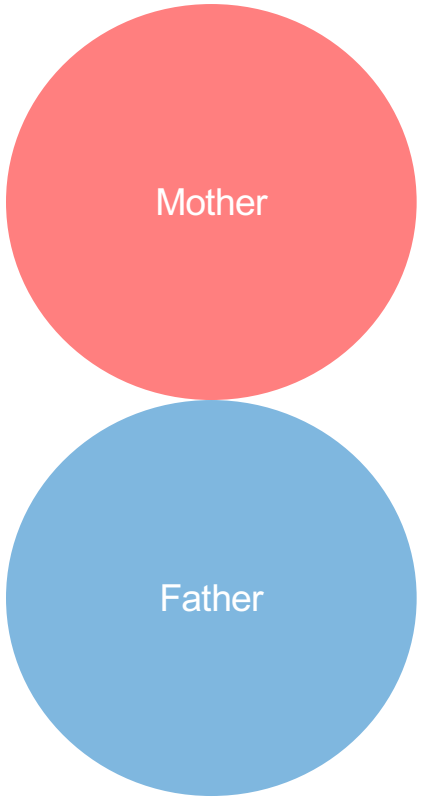
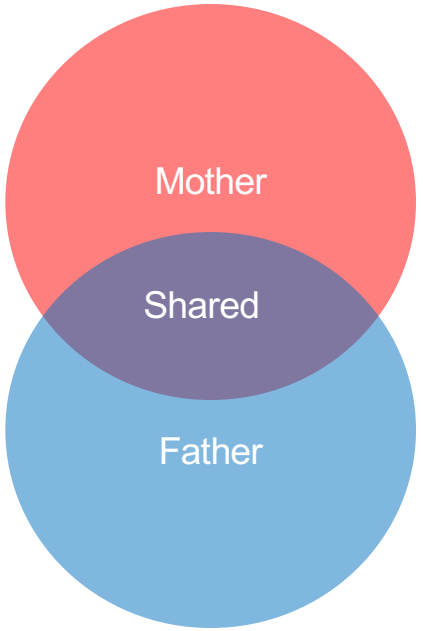
Conceptual Representation of Similarity

No Similarity



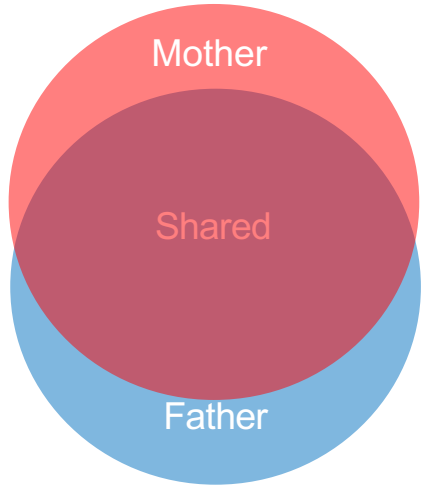
ICC = -1.0

Slight Similarity



ICC = .30

High Similarity



ICC = .75

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The Intraclass Correlation Coefficient (ICC)

- Scholars argue that the intraclass correlation coefficient (ICC) is an effective measure of similarity
  - The ICC takes into account the similarity between two individuals in the value of their scores, rather than the correlation between scores
    - The ICC is traditionally used as a measure of inter-rater reliability (Hallgren, 2012)
  - The ICC can also be adjusted for stereotype accuracy

Kenny, Kashy, & Cook (2006)

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Stereotype Accuracy

- Dyad members are often similar to one another because they share views held by most people in a population
- Two randomly selected individuals might have a degree of similarity in their responses
- In dyadic-research, we are usually curious if members of a dyad are more (or less) similar than would be expected by chance
    - Do spouses from a given dyad report more (or less) similarity than a randomly selected man and woman?

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Adjustment for Stereotype Accuracy

- The mean for each item should be subtracted before computing the ICCs
  - In effect, this makes the ICC a measure of how similar the dyad members' deviation scores are

- In analyses with distinguishable dyads, use the group mean
  - For example, the mean for wives' scores should be used separately from the husbands' mean scores

Kenny, Kashy, & Cook (2006)

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Using the ICC in Research

- Independent variables
  - How does similarity relate to other constructs?
- Dependent variables
  - What is predictive of more similarity in perceptions?
- Moderator variables
  - Do variables have a stronger or weaker association based on the level of similarity in the dyad?

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Methodological Limitations

- Assumption of ICCs
  - The factor structure of the measure is similar for both dyad members
  - If dyad members interpret the items differently, this may affect their similarity score

- Missing data
  - Item-level data would need to be imputed, or missing ICC values would need to be addressed with multiple imputation or FIML estimation

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Latent Variable Modeling Approaches
Latent Congruence / Difference Models

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Latent Variable Approaches

- Operationalization of congruence (agreement, fit, similarity) has been challenging
  - Difference scores and similarity indices criticized as having lower reliability than individual component variables; disguise contributions of individual components on dependent variables

- Structural equation modeling approaches have been proposed to overcome manifest variable issues
  - Latent Difference Model (Newsom, 2002)
  - Latent Congruence Model (Cheung, 2009)

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Latent Congruence/Difference Models

- Structural equation modeling–based
  - Uses a latent variable that captures aspects of the dyad

- What do these approaches measure?
  - Mean (absolute level)
    - What is the average rating of relationship quality across parents and teachers?
  - Difference (some refer to as congruence)
    - How different are teacher and parent reports on the quality of their relationship?

- Unit of Analysis
  - Dyad

Cheung, 2009; Newsom, 2002

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Advantages

- Offers many advantages over other approaches
  - *E.g., Differences scores, profile similarity indices, polynomial regression*
  - Inclusion of measurement error
  - Provides a method to test measurement equivalence
  - Simultaneous examination of antecedents and consequences of both the mean (absolute level) and difference (congruence)

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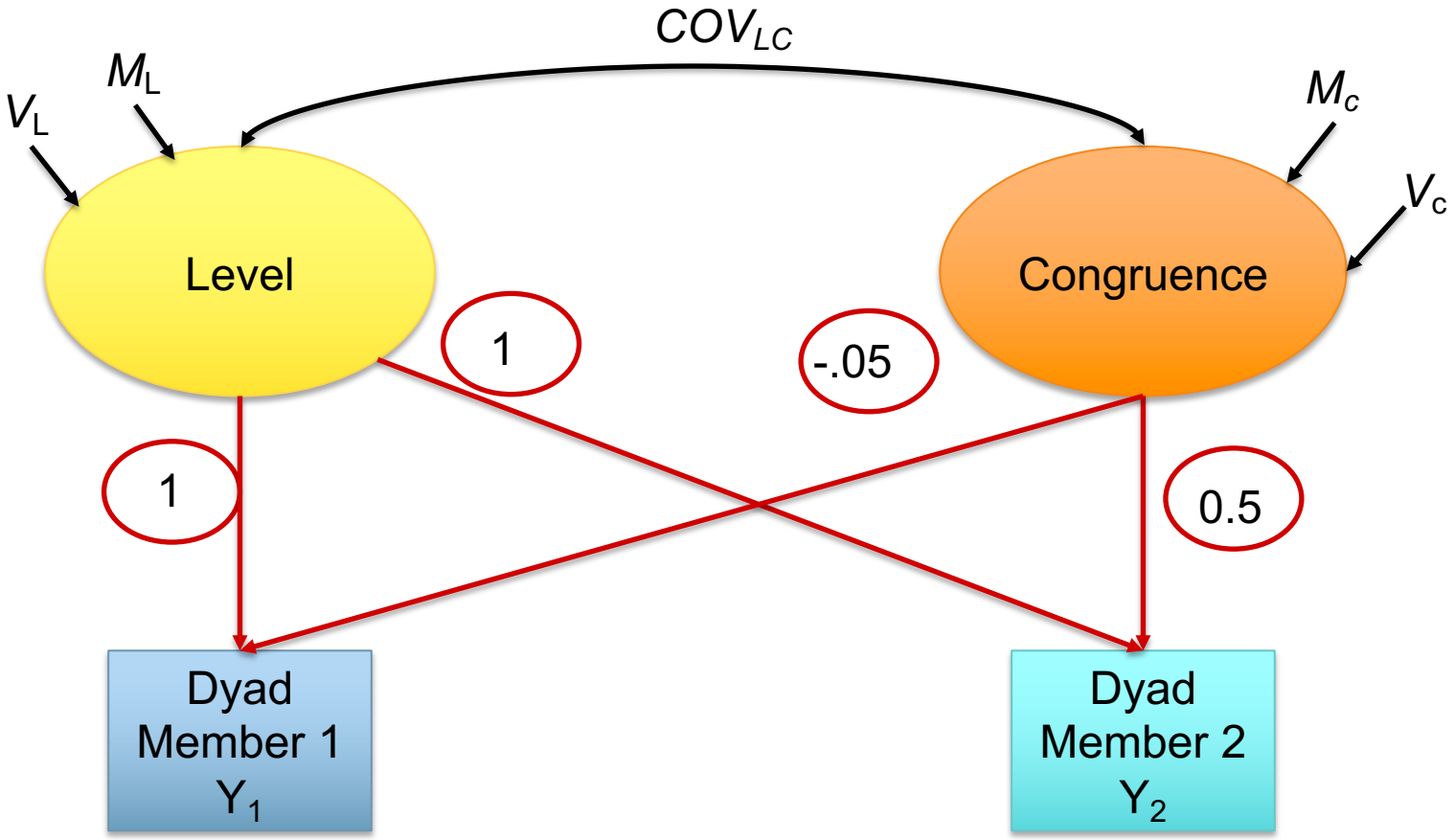
Basic Latent Congruence Model



Key

Y_1 and Y_2 = interdependent observed variables

Level = $Y_1 + Y_2 / 2$

Congruence = $Y_2 - Y_1$

M_L = mean of factor *Level* represents the grand mean of the mean rating of Y1 and Y2

V_L = variance of factor *Level* represents the variance of the mean rating of Y1 and Y2

M_c = mean of factor *Congruence* represents the average difference between Y1 and Y2

V_c = variance of factor *Congruence* represents the variance of the difference of Y1 and Y2

COV_{LC} = covariance of Level of Congruence

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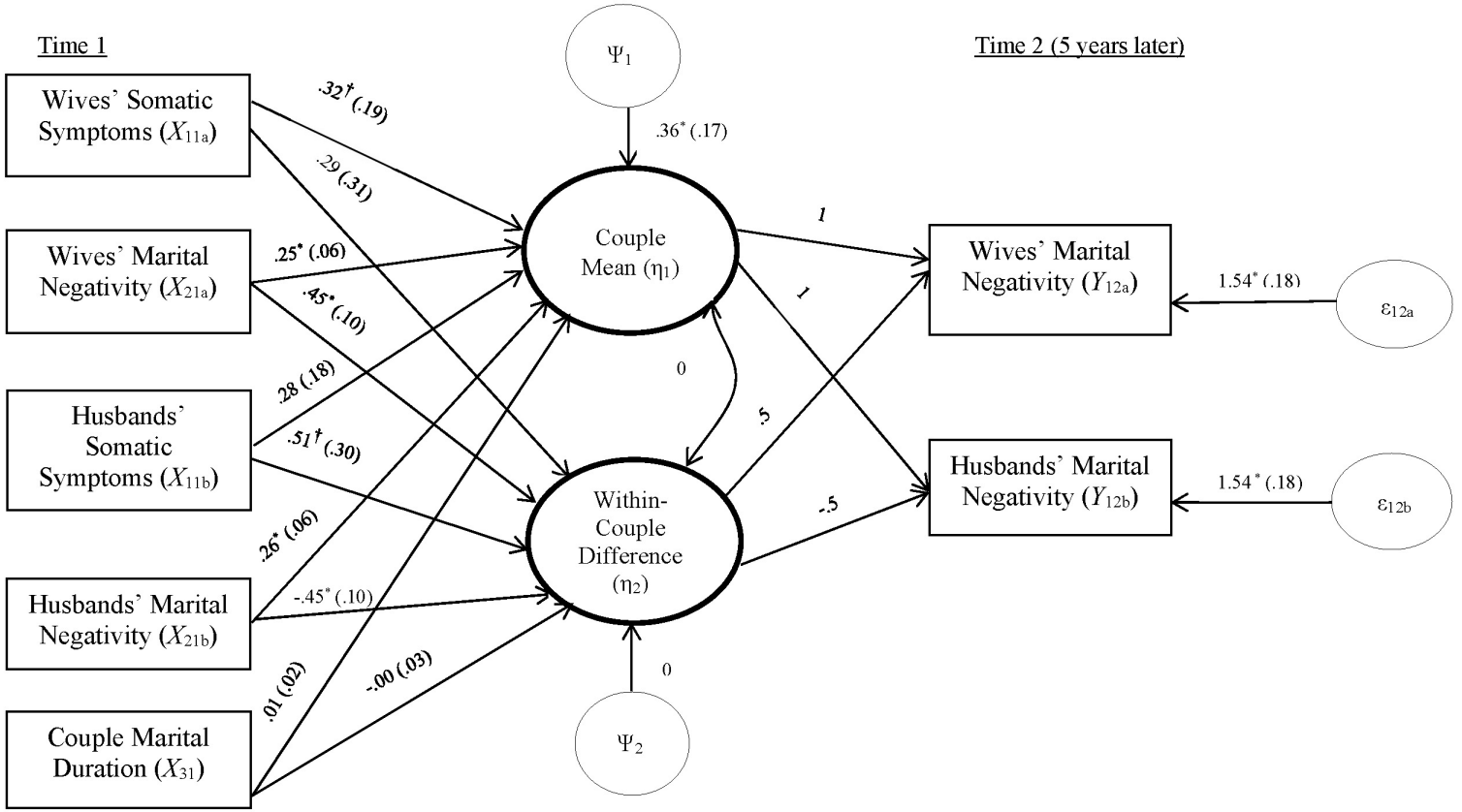
Example 1: Juntos Project

- Examined within-couple factors that predicted discrepancies in Mexican-origin spouses' marital negativity
  - High levels of wives' marital negatively linked to more discrepant reports of marital negativity within couples 5 years later
  - High levels of husbands' marital negativity related to more similar reports of marital negativity within couples 5 years later



Wheeler et al., 2018, *Journal of Latina/o Psychology*

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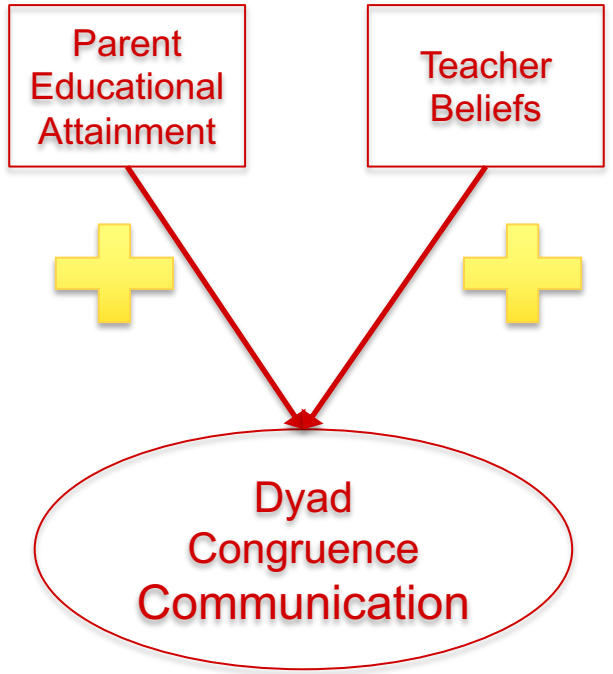
Example 2: CBC Projects

What factors relate to dyadic congruence between parents and their children's teachers reports of p-t relationship quality?

- High levels of parental educational attainment related to less difference (**more congruence)** in parent and teacher reports of quality *Communication* (b = -.132, p < .05)
- High levels of teacher beliefs about parental involvement in school related to less difference **(more congruence)** in parent and teacher reports of quality *Communication* (b = -.030, p = .05)



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Brown, Chen, Sheridan, Wheeler et al., 2021, *National Association of School Psychologists Annual Conference*

Latent Variable Modeling Approach Measuring Interdependence Patterns

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Actor-Partner Interdependence Model (APIM)

- “Integrate a conceptual view of interdependence with the appropriate statistical techniques for measuring and testing it" (Cook & Kenny, 2005, p101)

- Take into account the nonindependence between two individuals, such as family members

- These models quantify within dyad effects
  - Actor effects (*a* paths)
  - Partner effects (*p* paths)
  - Dyadic index: patterns of interdependence = *k* parameter

Cook & Kenny, 2005; Kenny & Ledermann, 2010

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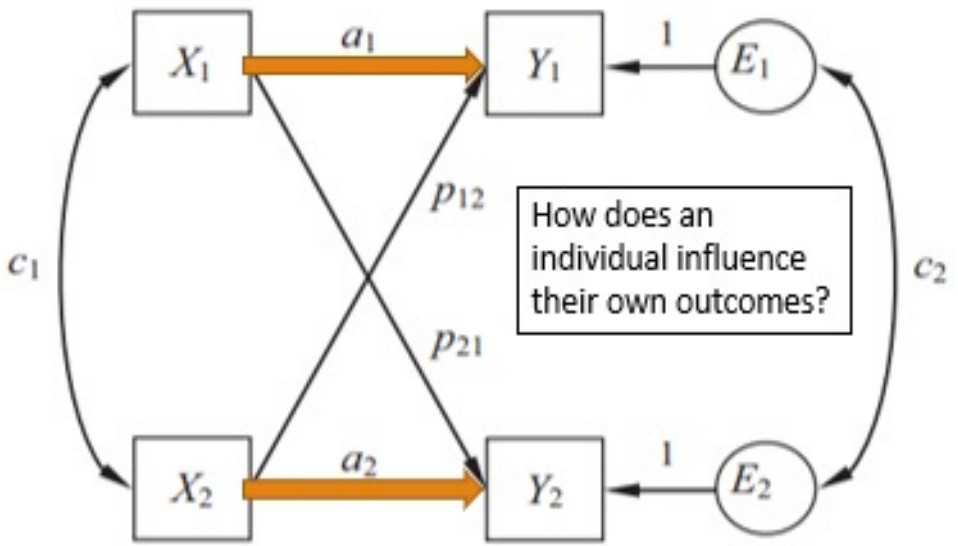
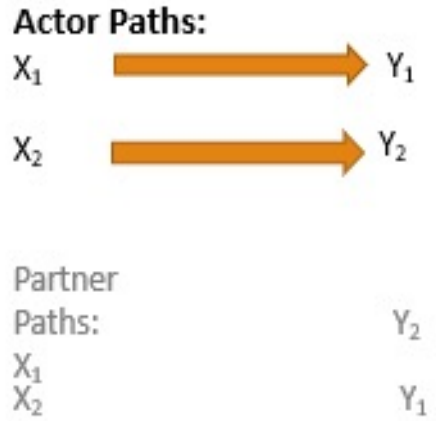
APIM Effects: Actor Effect

The extent to which an individual's independent variable relates to **their own** dependent variable





Kenny & Ledermann, 2010

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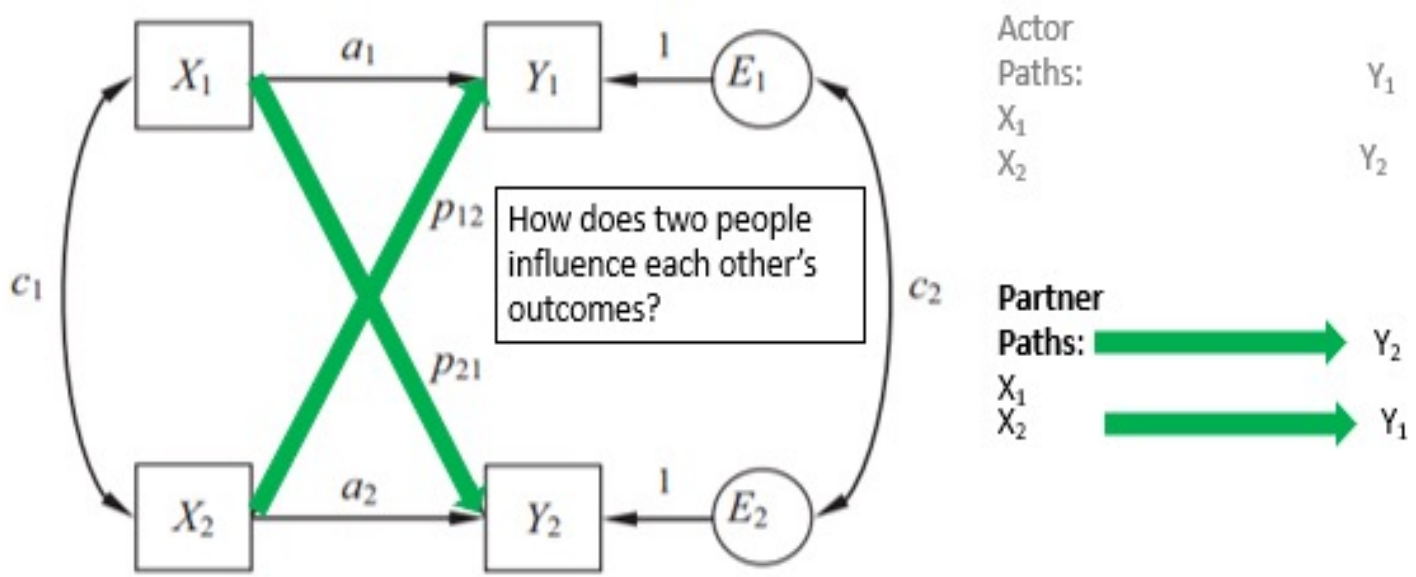
APIM Effects: Partner Effect

The extent to which an individual's independent variable relates to **their partner's** dependent variable



Kenny & Ledermann, 2010

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Dyadic Interdependence Patterns

- Actor Pattern
- Couple Pattern
- Contrast Pattern

k parameter: Kenny & Ledermann, 2010

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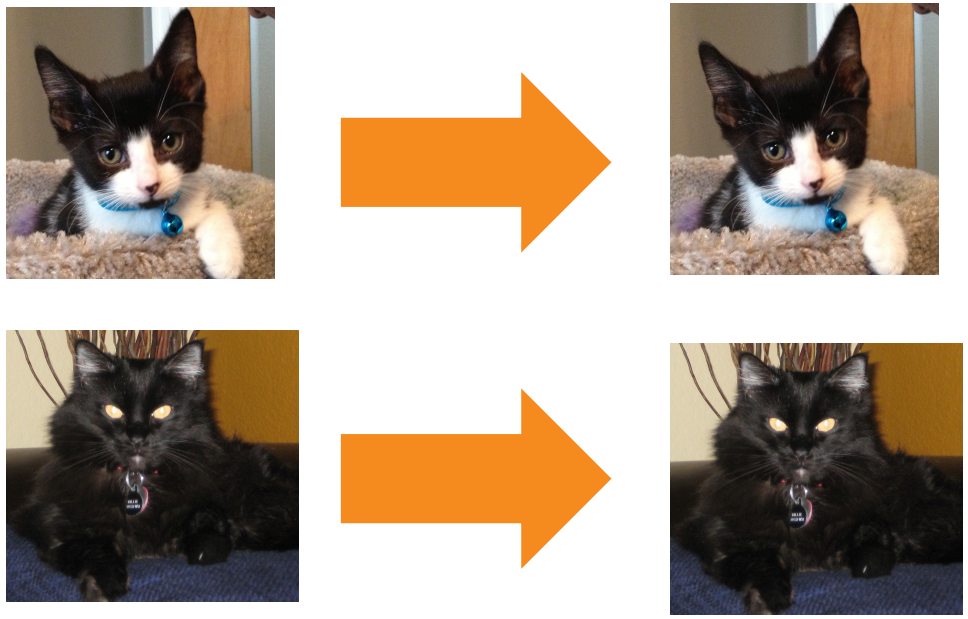
Actor-only

Member 1

Member 2



- This pattern suggests an actor focus or actor driven process
- No significant partner effects

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Member 1

Member 2

Couple Pattern

- This patterns indicates the presence of significant partner effects, in addition to actor effects
- Suggests an orientation toward the couple/dyad

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Member 1

Member 2

Contrast Pattern

- Indicates the significant actor and partner paths are in the opposite direction

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Operationalization: *k* parameter

- *k* parameter = ratio (partner coefficient divided by the actor coefficient)
  - Estimate for each dyad member – can test to determine if k is the same or varies across dyad members
    - E.g., Is dyad member 1 individual (actor pattern) focused, whereas dyad member 2 couple oriented?
- Estimation using phantom latent variables
  - Latent variables without disturbance terms to force linear constraints on the model
  - Constraints allow for the quantification of the pattern of influence and statistically tests of this pattern as equal to 0, 1, or -1
- Actor coefficients need to be nontrivial to estimate *k*
  - Standardized regression coefficients > .10

Kenny & Ledermann, 2010

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k Parameter

- ***k* = 0; Actor Pattern**
- ***k* = 1; Couple Pattern**
- ***k* = -1; Contrast Pattern**

Kenny & Ledermann, 2010

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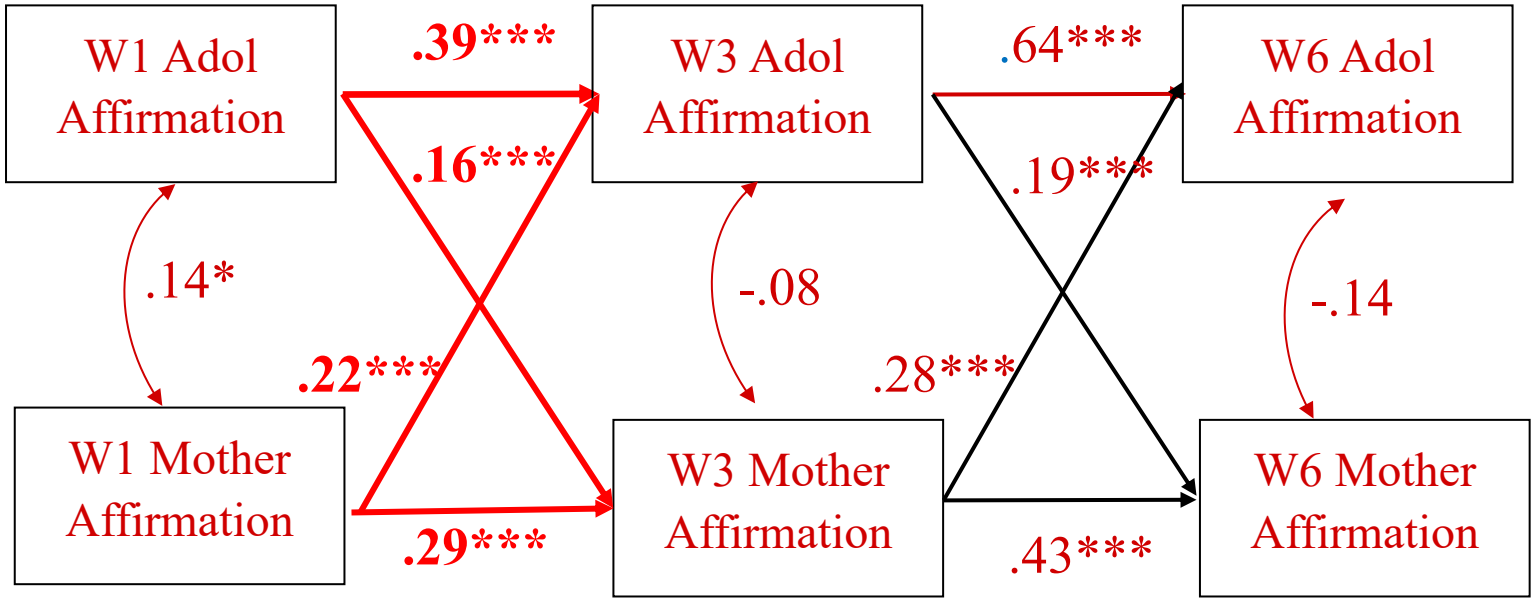
Example 3: MAMI Project
Coevolution of Ethnic-Racial Identity - Affirmation



- A couple pattern emerged from W1 to W3 (K = .70, 95% CI [.08, 2.30])
- During the process of ERI affirmation development, mothers and adolescents are influenced by the dyad

Model fit: $\chi^2(29) = 59.13$, $p<.001$; CFI = .86; TLI = .82; SRMR = .07; RMSEA = .07, 90% C.I. [.05, .10]

Martinez-Fuentes, Umaña-Taylor, Delay, Wheeler, et al., 2021, *Society for Research in Child Development Biennial Meeting*

Thank you!
Questions?

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References, Resources, and Examples

- Ackerman, R. A., Donnellan, M. B., & Kashy, D. A. (2011). Working with dyadic data in studies of emerging adulthood: Specific recommendations, general advice, and practical tips. In F. D. Fincham & M. Cui (Eds.), *Romantic relationships in emerging adulthood* (pp. 67-100). New York: Cambridge University Press.
- Cook, W. L., & Kenny, D. A. (2005). The actor–partner interdependence model: A model of bidirectional effects in developmental studies. *International Journal of Behavioral Development, 29(2),* 101-109.
- Deal, J. E., Wampler, K. S., & Halverson, C. F. (1992). The importance of similarity in the marital relationship. *Family Process, 31(4)*, 369-382.
- Garbacz, S. A., Sheridan, S. M., Koziol, N. A., Kwon, K., & Holmes, S. R. (2015). Congruence in parent–teacher communication: Implications for the efficacy of CBC for students with behavioral concerns. *School Psychology Review, 44(2)*, 150-168.
- Gonzalez, R., & Griffin, D. (1997). On the statistics of interdependence: Treating dyadic data with respect. *Handbook of personal relationships, 2*, 271-301.
- Kashy, D. A., & Levesque, M. J. (2000). Quantitative methods in close relationships research. In C. Hendrick & S. S. Hendrick
- (Eds.), *Close relationships: A sourcebook*. (pp.3-17). Thousand Oaks, CA, US: Sage Publications, Inc.
- Kenny, D. A., Kashy, D. A., & Cook, W. L. (2006). *Dyadic data analysis*. Guilford Press.
- Kenny, D. A., & Ledermann, T. (2010). Detecting, measuring, and testing dyadic patterns in the actor–partner interdependence model. *Journal of Family Psychology, 24*, 359.
- Ledermann, T., & Kenny, D. A. (2012). The common fate model for dyadic data: variations of a theoretically important but underutilized model. *Journal of Family Psychology, 26*, 140-148.
- Ledermann, T., Macho, S., & Kenny, D. A. (2011). Assessing mediation in dyadic data using the actor-partner interdependence model. *Structural Equation Modeling: A Multidisciplinary Journal, 18*, 595-612.
- Lyons, K. S., & Sayer, A. G. (2005). Longitudinal dyad models in family research. *Journal of Marriage and Family, 67*, 1048-1060.
- Newsom, J. T. (2002). A multilevel structural equation model for dyadic data. *Structural Equation Modeling, 9*, 431-447.
- Wendorf, C. A. (2002). Comparisons of structural equation modeling and hierarchical linear modeling approaches to couples' data. *Structural Equation Modeling, 9*, 126-140.
- Wheeler, L.A., Updegraff, K.A., & Thayer, S. (2010). Conflict resolution in Mexican-origin couples: Culture, gender, and marital quality. *Journal of Marriage and Family, 72*, 991-1005.
- Wheeler, L. A., Updegraff, K. A., & Umaña-Taylor, A. J. (2018). A dyadic data analytic primer: An illustration with Mexican-origin couples. *Journal of Latina/o Psychology, 6*, 276-290. https://doi.org/10.1037/lat0000118

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