Evaluating the Direct and Indirect Effects of Early Intervention Practices Using Meta-Analytic Structural Equation Modeling

Carl J. Dunst Carol M. Trivette
Orelena Hawks Puckett Institute
Asheville and Morganton, North Carolina

Presentation made at the U.S. Department of Education, Office of Special Education Programs Project Directors' Conference, Washington, DC, July 21, 2010.

Purpose of the Session

- Describe how meta-analysis and structural equation modeling can be integrated and used to test the manner in which intervention variables are directly and indirectly related to child, parent, or family outcomes

- Illustrate how meta-analytic structural equation modeling can identify pathways of influence between intervention and outcome variables as well as variables that mediate the relationships between the interventions and the outcomes

A Brief Description and Examples of:

- Meta-Analysis
- Structural Equation Modeling

Meta-Analysis

A procedure for combining (integrating) findings from multiple studies investigating the same or similar intervention (independent) variables and the same or similar outcome (dependent) variables to determine the overall strength of the relationship between the two sets of variables. The size of effect for the relationship provides a more precise estimate of the effect of an intervention variable on an outcome variable.

Effect Sizes

Effect sizes rather than statistical significance are used to determine the relationships between independent and dependent variables in a meta-analysis. An effect size is a way of quantifying the differences between groups or the relationship between two variables. It is common practice to use standardized effect sizes because they mean the same thing for different studies. Two commonly used effect sizes are:

- Cohen's *d*
- Correlation coefficient

Two Families of Effect Sizes[a]

- Contrast Effect Sizes

  These effect sizes are used to determine the differences between two groups on an outcome measure where the two groups had different experiences (e.g., intervention group vs. control group).

- Correlation Effect Sizes

  These effect sizes are used to determine the strength of the relationship between two variables for the same group of individuals (e.g., the relationship between frequency of an intervention and amount of child progress).

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[a] R.L. Rosnow, R. Rosenthal, D.B. Rubin. (2000). Contrasts and correlations in effect-size estimation. *Psychological Science*, 446-453.

An Example of a Meta-Analysis Using Contrasts Effect Sizes

Meta-Analysis of the Effectiveness of Four Adult Learning Methods and Strategies[a]

Carl J. Dunst Carol M. Trivette Deborah W. Hamby

Adult Learning Methods: Accelerated learning, coaching, guided design, just-in-time training

Studies: 58 randomized controlled design studies (N=2,095 experimental and 2,213 control group participants)

Coding: Six characteristics of the adult learning methods were coded and related to the study outcomes (instructor introduction and illustration of new knowledge or practice, and learning application, evaluation, reflection, and self-assessment of mastery of the knowledge or practice)

Outcomes: Learner knowledge, skills, attitudes, and self-efficacy beliefs

Measure of Effect Size: Cohen's *d* effect size for between group post-test differences

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[a] *International Journal of Continuing Education and Lifelong Learning,* in press.

Cohen's *d* Effect Sizes for the Different Adult Learning Method Characteristics and Practices

Characteristics/Practices	Number		Mean Effect Size	95% Confidence Interval	*Z*
	Studies	Effect Sizes			
Introduction					
Out of class activities/self instruction	9	11	.64	.52-.77	10.43**
Classroom/workshop lectures	21	31	.63	.53-.72	13.14**
Pre-class exercises	5	5	.54	.38-.71	6.44**
Illustration/Demonstration					
Role playing/simulations	14	21	.55	.42-.68	8.20**
Learner input	4	4	.53	.34-.72	5.41**
Real life example/real life + role playing	3	4	.45	.14-.76	2.85*
Practicing					
Real life application	9	13	.94	.79-1.09	12.15**
Real life application + role playing	5	7	.86	.61-1.03	6.75**
Problem solving tasks	13	19	.49	.39-.58	10.10**
Evaluation					
Assess strengths/weaknesses	7	9	.94	.65-1.22	6.49**
Review experience/make changes	16	24	.47	.38-.56	10.19**
Reflection					
Performance improvement	4	6	1.27	.89-1.65	6.56*
Journaling/behavior suggestion	5	5	.82	.52-1.12	5.33**
Group discussion about feedback	13	19	.49	.39-.58	10.10**
Mastery					
Standards-based assessment	8	11	.86	.72-.99	12.47**
Self assessment	13	19	.49	.39-.58	10.10**

* p. <01. ** p <.0001.

An Example of a Meta-Analysis of Correlation Effect Sizes

Meta-Analysis of Family-Centered Help-giving Practices Research[a]

Carl J. Dunst C.M. Trivette Deborah W. Hamby

Family-Centered Practices: Relational and participatory helpgiving practices measured by 12 different family-centered practices scales

Studies: 47 studies conducted in 7 countries (N=11,187 study participants)

Outcomes: Parent satisfaction, self-efficacy beliefs, social support, child behavior functioning, parent and family well-being, and parenting competence and confidence

Measure of Effect Size: Correlation coefficient for the relationship between relational and participatory practices and the study outcomes

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[a] *Mental Retardation and Developmental Disabilities Research Reviews*, 2007, *13*, 370-378.

Effect Sizes for the Relationship Between Relational and Participatory Practices and the Outcomes Measures

	Relational Helpgiving Practices				Participatory Helpgiving Practices			
	Number		Effect Size[a]		Number		Effect Size[a]	
Outcome Measures	Sample Size	Effect Size	Mean	95% CI	Sample Size	Effect Size	Mean	95 % CI
Participant Satisfaction								
Satisfaction with Staff	601	4	.67****	.63-.72	526	5	.38****	.34-.42
Satisfaction with Program	1598	20	.63****	.62-.65	1598	8	.67****	.65-.70
Self Efficacy Beliefs								
Practitioner Control	1368	10	.62****	.59-.65	1368	11	.62****	.59-.66
Program Control	754	10	.70****	.66-.73	754	13	.67****	.64-.70
Life Events Control	675	12	.32****	.26-.38	913	19	.39****	.35-.43
Program Resources								
Parent/Child Supports	181	4	.26****	.17-.36	181	4	.37****	.28-.46
Program Helpfulness	252	2	.47****	.37-.56	252	2	.52****	.43-.61
Child Behavior								
Positive Child Behavior	345	8	.25****	.19-.31	345	5	.34****	.27-.41
Negative Child Behavior	93	8	.25****	.18-.31	93	4	.20****	.11-.30
Behavioral Competence	252	3	.24****	.14-.34	252	3	.18***	.08-.28
Well-Being								
Personal Well-Being	1543	26	.27****	.25-.30	1543	16	.26****	.22-.30
Family Well-Being	245	4	.18****	.11-.27	245	4	.29****	.23-.37
Parenting Behavior								
Confidence	331	3	.16**	.06-.27	331	4	.26****	.18-.35
Competence	236	2	.05	-.07-.18	236	3	.11*	.01-.21
Enjoyment	331	3	.15**	.05-.26	331	4	.24****	.16-.35

*p < .05. **p < .01. ***p < .001. ****p < .0001.

Structural Equation Modeling

A procedure for evaluating how a set of variables are related to one another in terms of causes and effects (i.e., pathways of influence). Structural equation modeling tests the fit of a proposed or hypothesized model to the pattern of relationships (e.g., correlations) among the variables in the model. Path diagrams are used to show how the variables in a model “go together.” How well the model fits the data is assessed by fit indices which tell us whether the model is accepted or rejected. Two of the many fit indices are:

- Comparative fit index
- Root mean square error of approximation

An Example of Structural Equation Modeling

Parent and Community Assets as Sources of Young Children's Learning Opportunities[a]

Carl J. Dunst

Participants: 100 low income mothers and their preschool age child(ren) in five public housing neighborhoods

Intervention: Number and frequency of child and parent-child participatory learning opportunities

Outcomes: Child engagement and positive affect and parent confidence and enjoyment in providing her child(ren) informal family and community learning opportunities

Predictions: Parents who successfully engaged their children in the learning activities would have positive outcomes on both the children and parents where the relationship between the participatory learning opportunities and parent outcomes was mediated by child benefits

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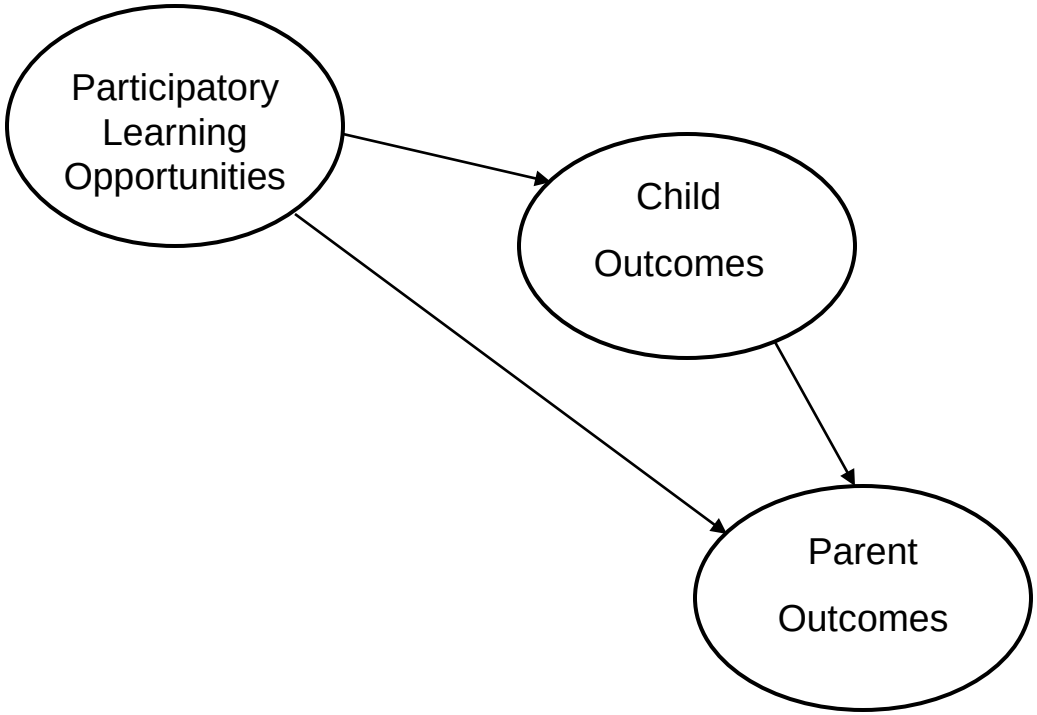
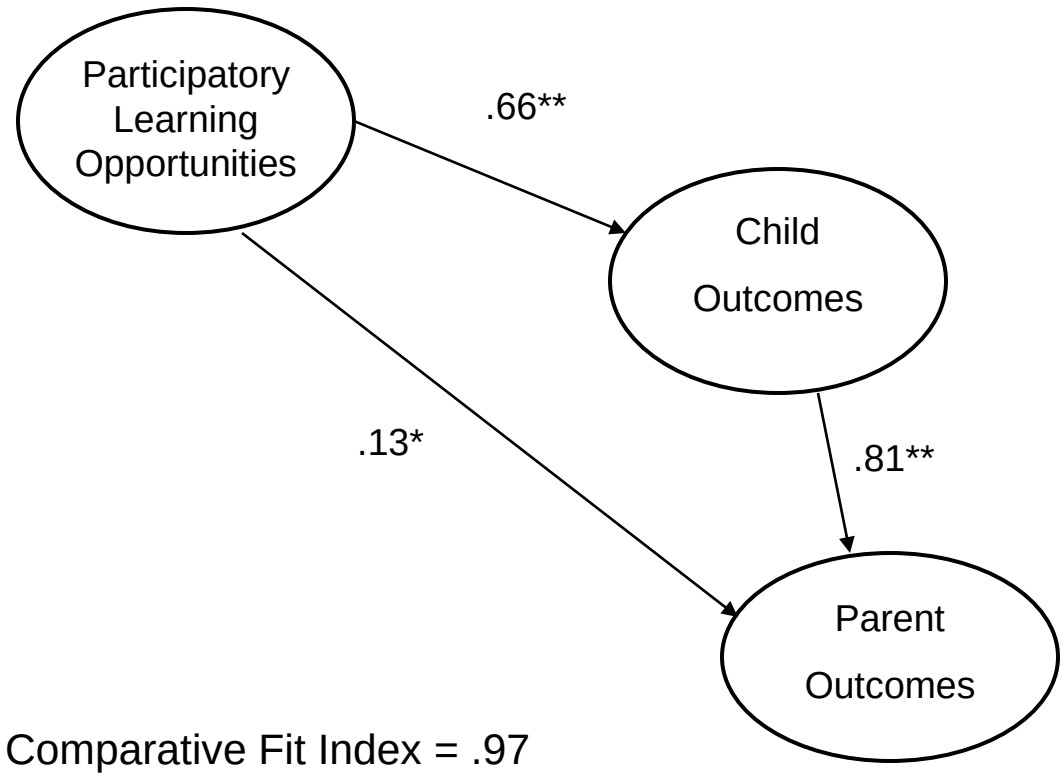
[a] *Winterberry Press Monograph Series*. Asheville, NC: Winterberry Press.

Path Diagram for the Relationships Among the Measures in the Model



Structural Equation Modeling Results



Effects Decomposition

Direct = .13

Indirect = .53

Total = .66

Comparative Fit Index = .97

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* $p < .06$. ** $p < .0001$.

Meta-Analytic Structural Equation Modeling

Meta-analytic structural equation modeling is a procedure for combining data (e.g., correlations) from multiple studies (meta-analysis) and using the combined data set to evaluate the fit of a model to the patterns of relationships among the variables in the model (structural equation modeling). Recent advances in data analysis procedures make meta-analytic structural equation modeling potentially useful for evaluating the effects of different kinds of intervention practices on outcomes of interest. Dr. Mike Cheung at the National University of Singapore has developed easy to use software[a] to prepare and analyze data to perform a MASEM.

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[a] Cheung, M.W.L. (2009). TSSEM: A LISREL syntax generator for two-stage structural equation modeling (Version 1.11) [Computer software manual]. Singapore: Author. Available at http://courses.nus.edu.sg/coursepsycwlm/internet/tssem.zip.

Two-Stage Structural Equation Modeling[a]

Stage 1. Test the homogeneity of a pooled correlation matrix and produce a weighted pooled correlation matrix. This involves two steps:

- 1A. Testing the homogeneity of a pooled matrix
- 1B. Producing a weighted correlation matrix if the pooled matrix is homogeneous

Stage 2. Testing the fit of a hypothesized model to the patterns of relationships among the variables in the pooled matrix using SEM. Two types of statistics are used to evaluate fit:

- 2A. Testing the fit of a model to the patterns of correlations among the variables in the model
- 2B. Estimate the strength of the relationships between the variables in a model

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[a] Cheung, M.W., & Chan, W. (2005). Meta-analytic structural equation modeling: A two-stage approach. *Psychological Methods*, 10(1), 40-64.

Stage 1A: Pooling Correlation Matrices

	Study 1		Study 2		Study 3		Pooled	
Variable 1	1.0		1.0		1.0		1.0	
Variable 2	.62	1.0	.49	1.0	-	-	.55	1.0
Variable 3	.33	.51 1.0	.37	.42 1.0	.42	- 1.0	.37	.46 1.0
Variable 4	.41	.32 .38 1.0	.45	.23 .27 1.0	.33	- .30 1.0	.40	.29 .32 1.0
			+		+		=	

The pooled correlation matrix is first evaluated to determine if the correlations among the measures in different studies are homogeneous

Stage 1B: Produce a Weighted Pooled Correlation Matrix

A weighted pooled correlation matrix adjusts the size of the correlations between variables by giving more weight to studies with larger sample sizes.

- If the correlations for large N studies are smaller than those for small N studies, the pooled correlation will be ***smaller*** than the average correlation
- If the correlations for large N studies are larger than those for small N studies, the pooled correlation will be ***larger*** than the average correlation

Stage 2A: Testing Model Fit

Model fit is a procedure used to assess “how well” the hypothesized model fits the overall relationships between the variables in a pooled correlation matrix. Different fit indices are available for this test. The recommended fit indices for two-stage meta-analytic structural equation modeling are:

- Comparative fit index
- Root mean square error of approximation

Stage 2B: Sizes of Effects in the Structural Equation Model

This step produces the effect sizes (parameter estimates) for each of the paths in a model. You can use either standardized or nonstandardized path coefficients as the sizes of effect. Standardized effect sizes can range between -1 and +1. We prefer standardized coefficients for several reasons:

- Measures of the same construct are generally not scaled the same in different studies
- All effect sizes can be interpreted in the same manner

An Example of a Meta-Analytic Structural Equation Modeling Analysis

Influences of Family-Centered Help-Giving on Parenting Confidence, Competence and Enjoyment

Studies: Eight studies that all included measures of family-centered practices, self-efficacy beliefs, and parenting confidence, competence and enjoyment.

Sample: N = 934 participants.

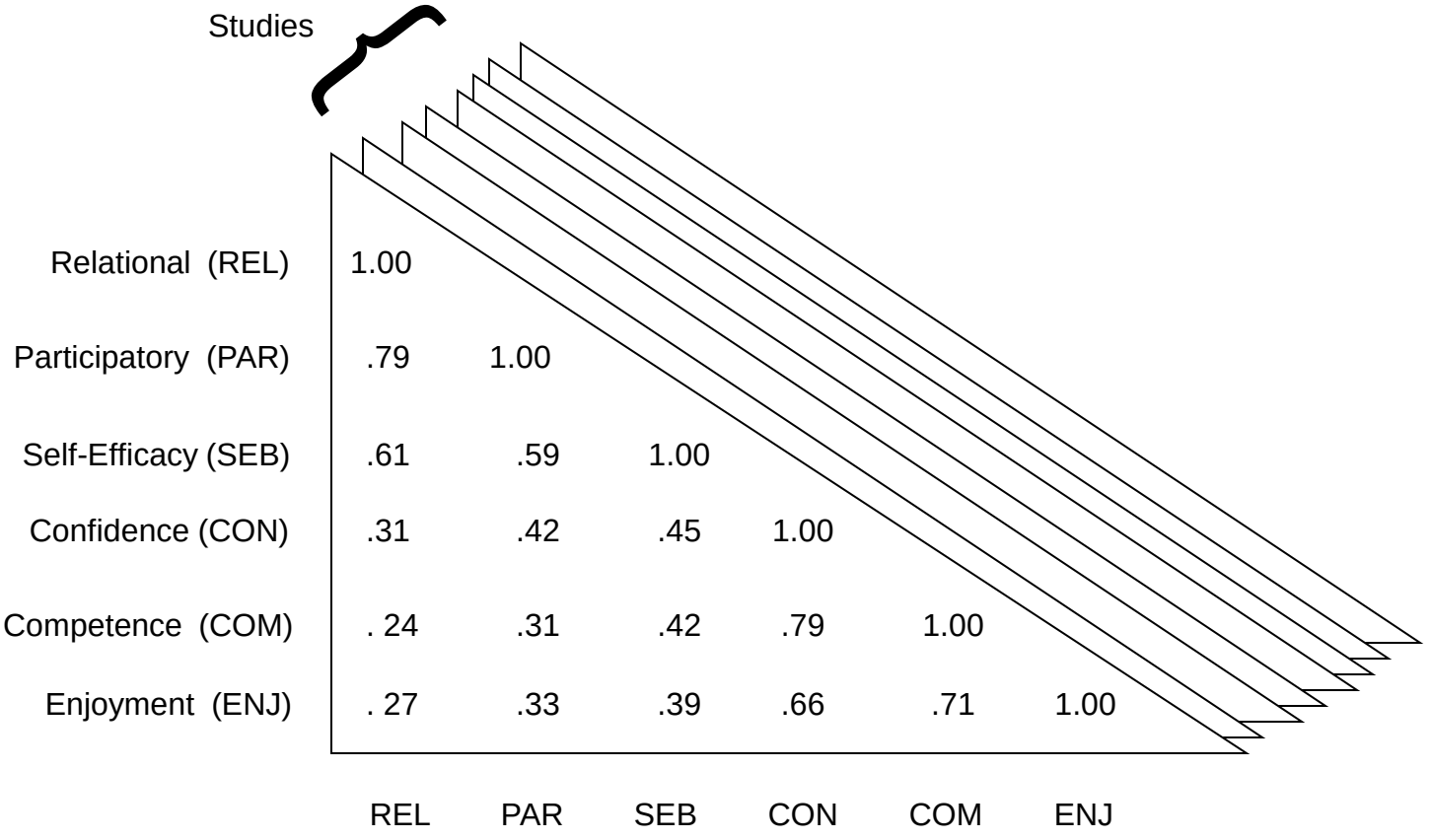
Family-Centered Practices Measures: Family-Centered Practices Scale, Enabling Practices Scale

Self-Efficacy Beliefs: Control appraisals of the ability to obtain the information and guidance, and supports and resources, from early intervention program staff.

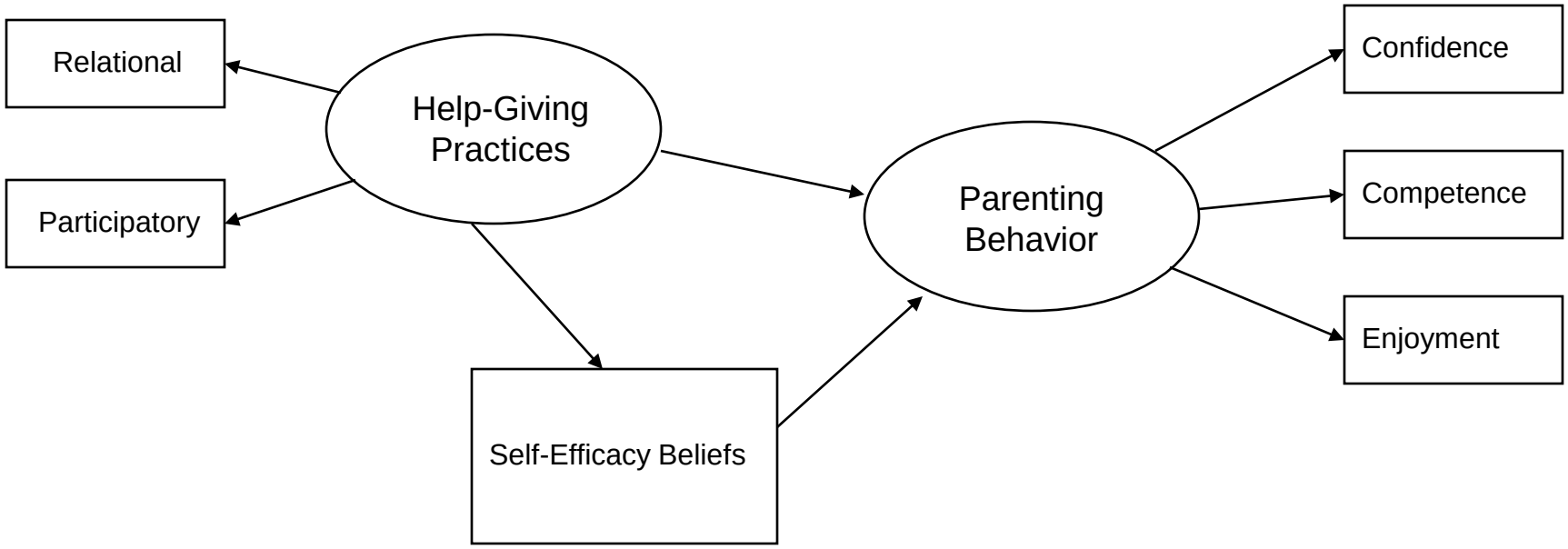
Parenting Capabilities: Everyday Parenting Scale

Hypothesis: Family-centered practices would be indirectly related to parenting confidence, competence and enjoyment mediated by self-efficacy beliefs.

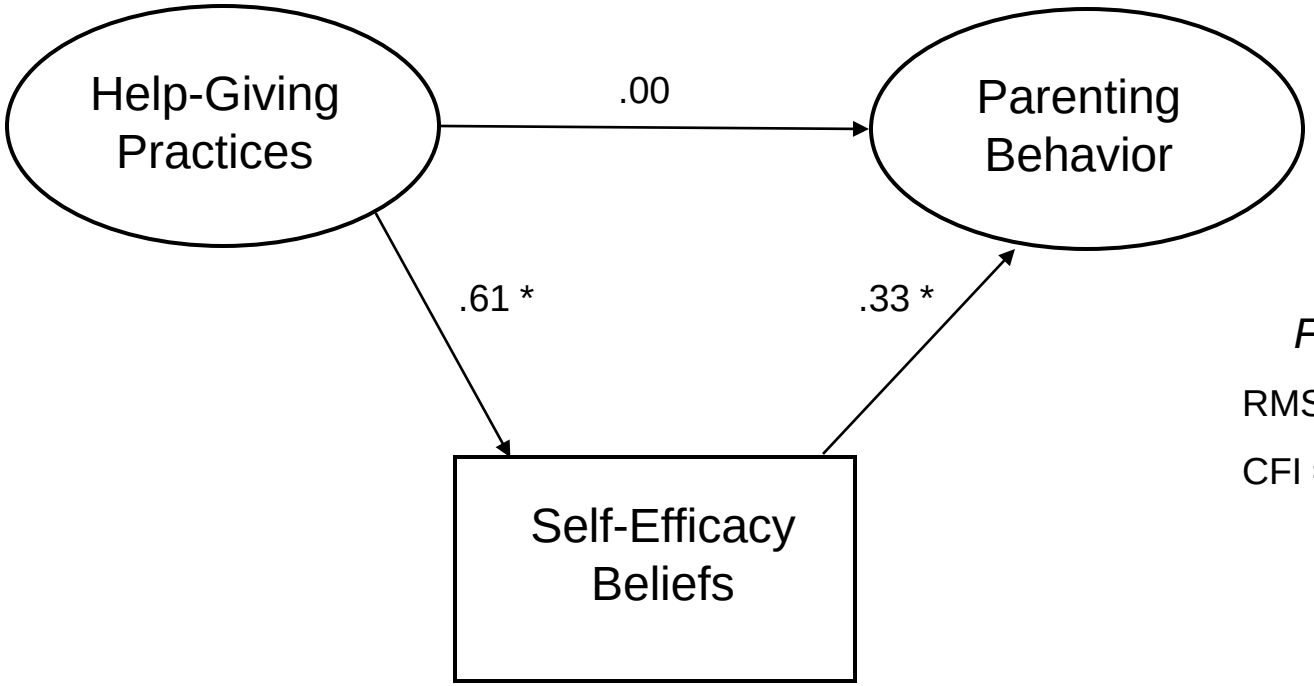
Stacked Correlation Matrices



Model for Testing the Direct and Indirect Effects of Family-Centered Practices or Parenting Behavior



Meta-Analytic Structural Equation Modeling Results



Fit Indices

RMSEA = .05

CFI = 1.00

* p < .0001.

Multi-Variable Model Examples

- Meta-analytic structural equation modeling of the influences of family-centered care on parent and child psychological health. *International Journal of Pediatrics,* 2009, Article ID 576840
- Influences of family-systems intervention practices on parent-child interactions and child development. *Topics in Early Childhood Special Education,* 2010, 30, 3-19.
- Meta-analytic structural equation modeling of the determinants and consequences of parenting self-efficacy beliefs. In F. Columbus (Ed.), *Parenting: Styles, Stresses and Strategies*. Hauppage, NY: Nova Science. (in preparation)
- Role of personal and situational child interests on early literacy development. (in preparation)
- Influences of child nursery rhyme knowledge on phonological awareness and later reading abilities. (in preparation)

Meta-Analytic Structural Equation Modeling of the Influences of Family-Centered Care on Parent and Child Psychological Health[a]

Carl J. Dunst Carol M. Trivette

Studies: 15 investigations of family-centered care that included measures of family-centered practices, self-efficacy beliefs, parent psychological health, and child psychological health

Sample: N= 2948

Family-Center Care Measures: Help-Giving Practices Scale, Family-Centered Practices Scale, and Enabling Practices Scale

Hypothesis: Based on contentions in the family-centered care literature, family-centered practices were expected to directly affect parent psychological health and parent health in turn affect child psychological health. Based on our own research, the relationships between family-centered care and parent and child health were expected to be mediated by self-efficacy beliefs.

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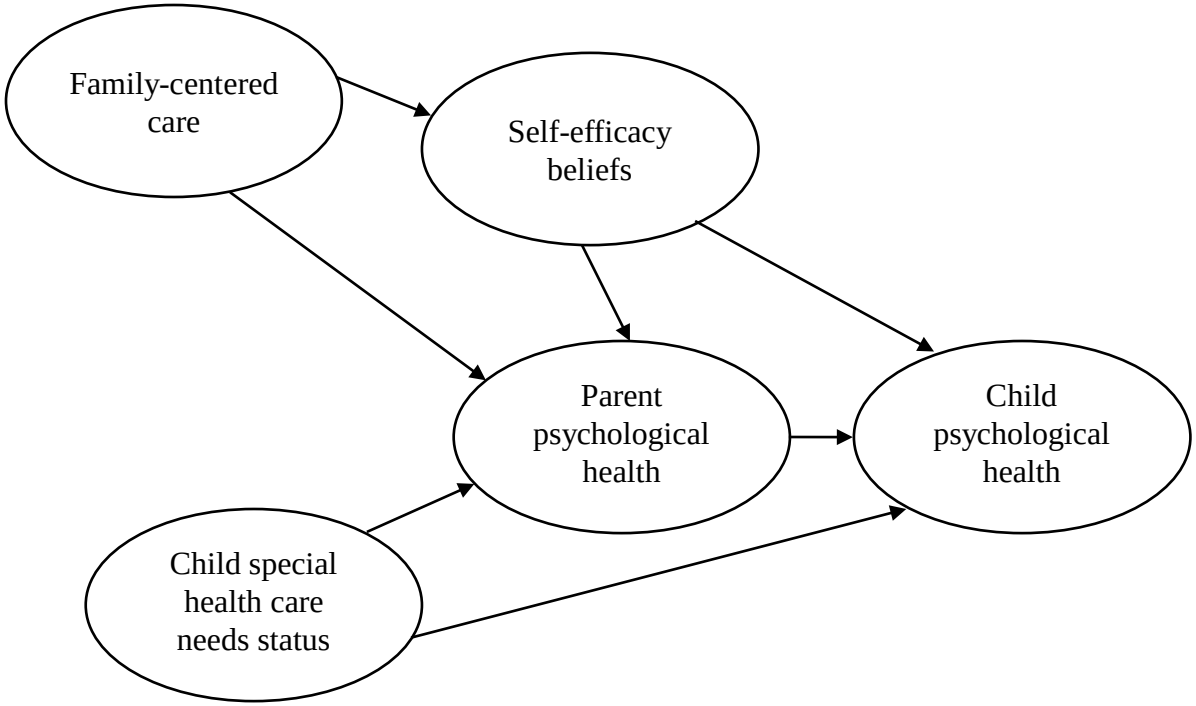
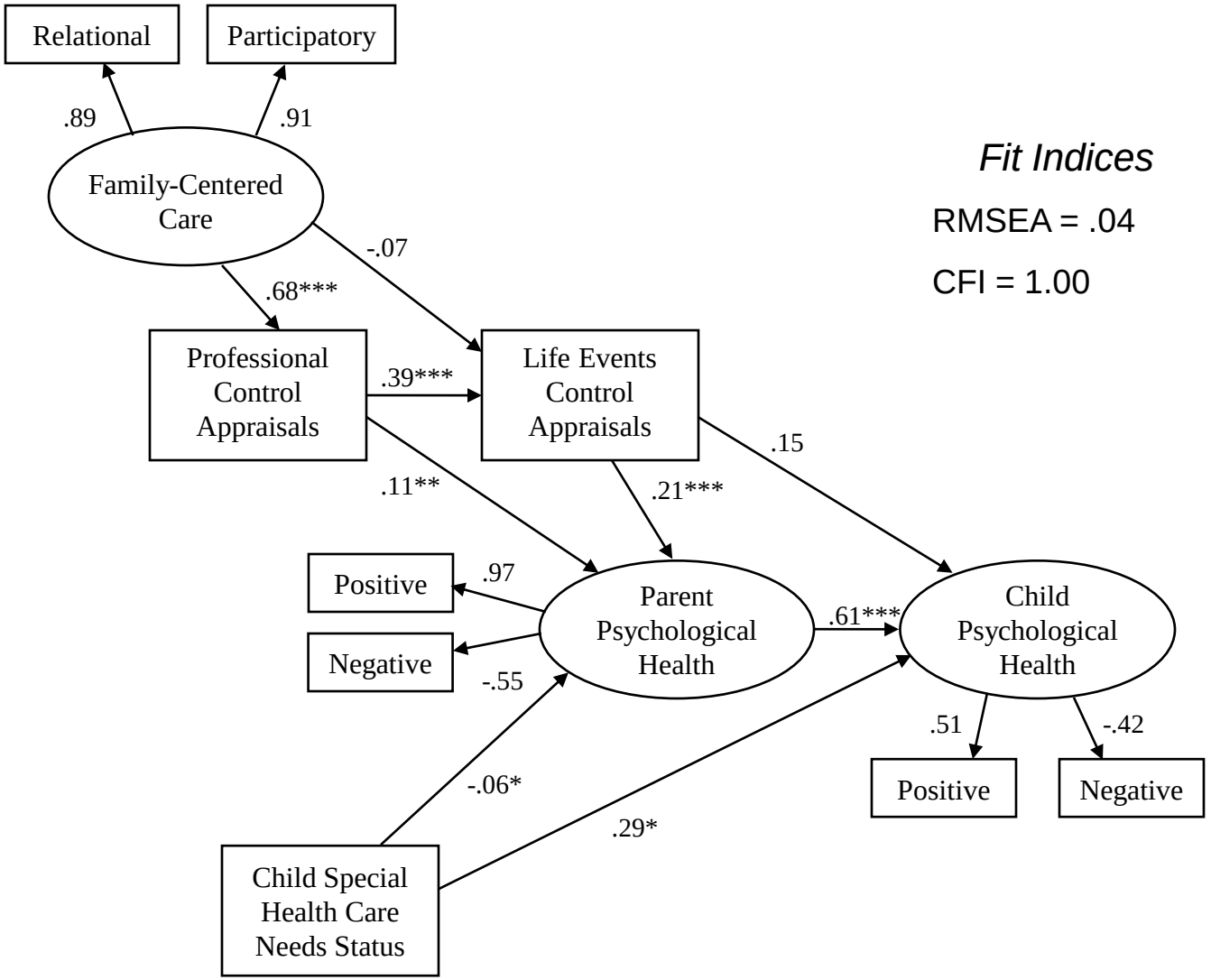
[a] *International Journal of Pediatrics*, 2009, Article ID 576840

Structural Equation Model for Evaluating the Effects of Family-Centered Care, Self-Efficacy Beliefs, and Child Special Health Care Needs on Parent and Child Psychological Health



Meta-Analytic Structural Equation Modeling Results



. *p < .01, **p < .001, ***p < .0001.

Influences of Family-Systems Intervention Practices on Parent-Child Interactions and Child Development[a]

Carol M. Trivette Carl J. Dunst Deborah W. Hamby

Studies: Eight studies that included measures allowing us to trace the effects of capacity-building help-giving practices and family-systems intervention practices on parent-child interactions and child development

Sample: 910 preschoolers and their parents involved in different kinds of help-giving programs

Predictions: The influences of help-giving and family-systems intervention practices on parent-child interactions and child development would be indirect and mediated by self-efficacy beliefs and parent well-being

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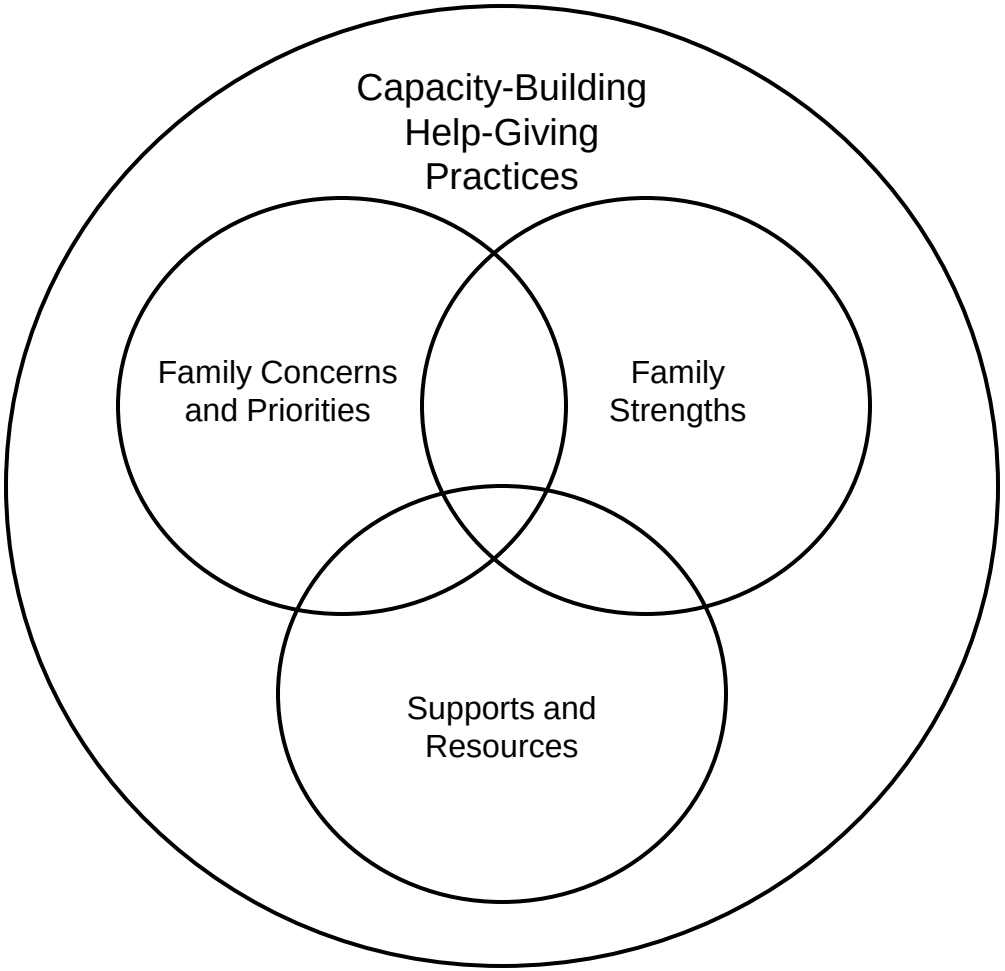
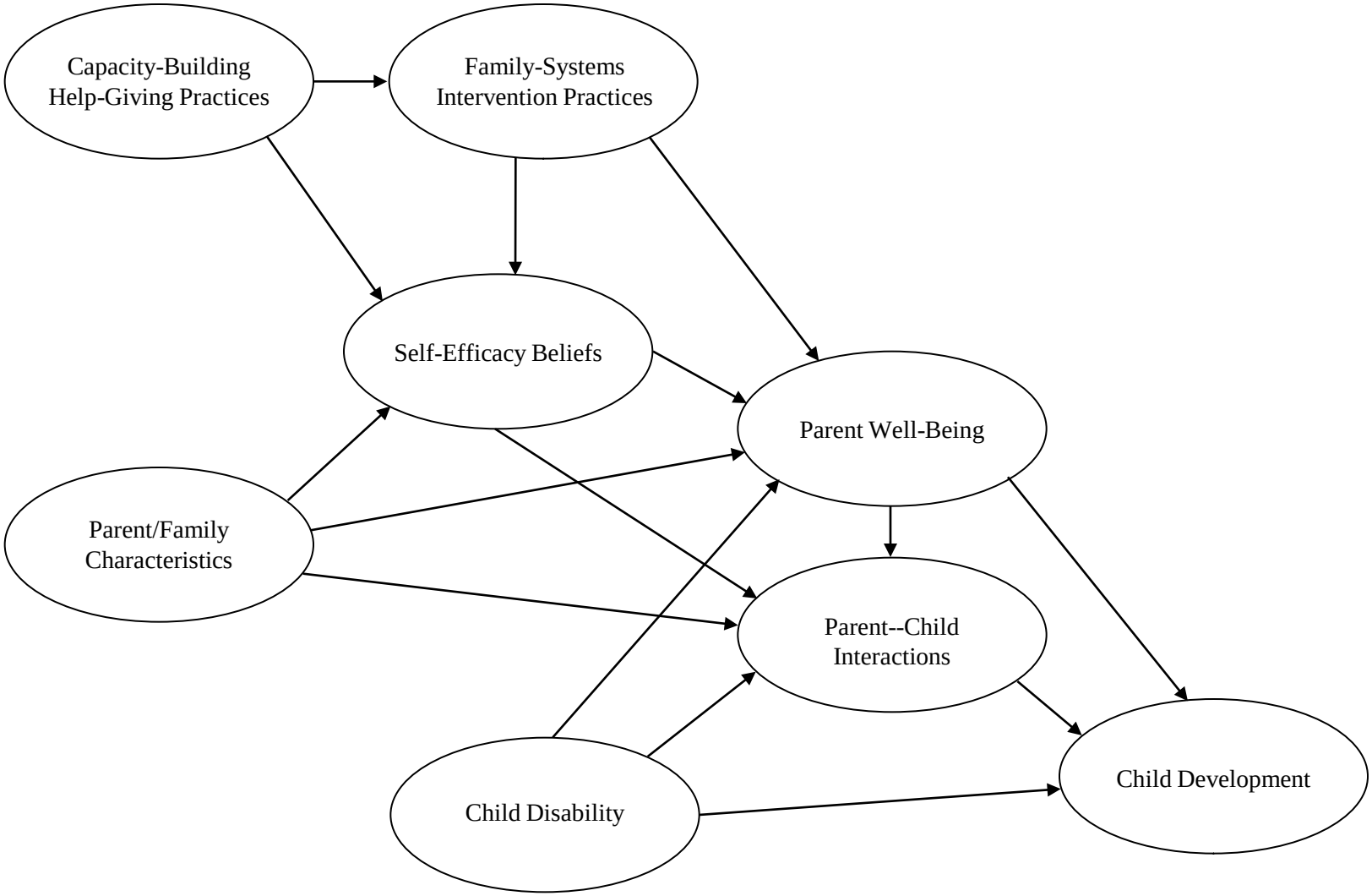
[a] *Topics in Early Childhood Special Education*, 2010, 30, 3-19.

Family-Systems Intervention Model[a]

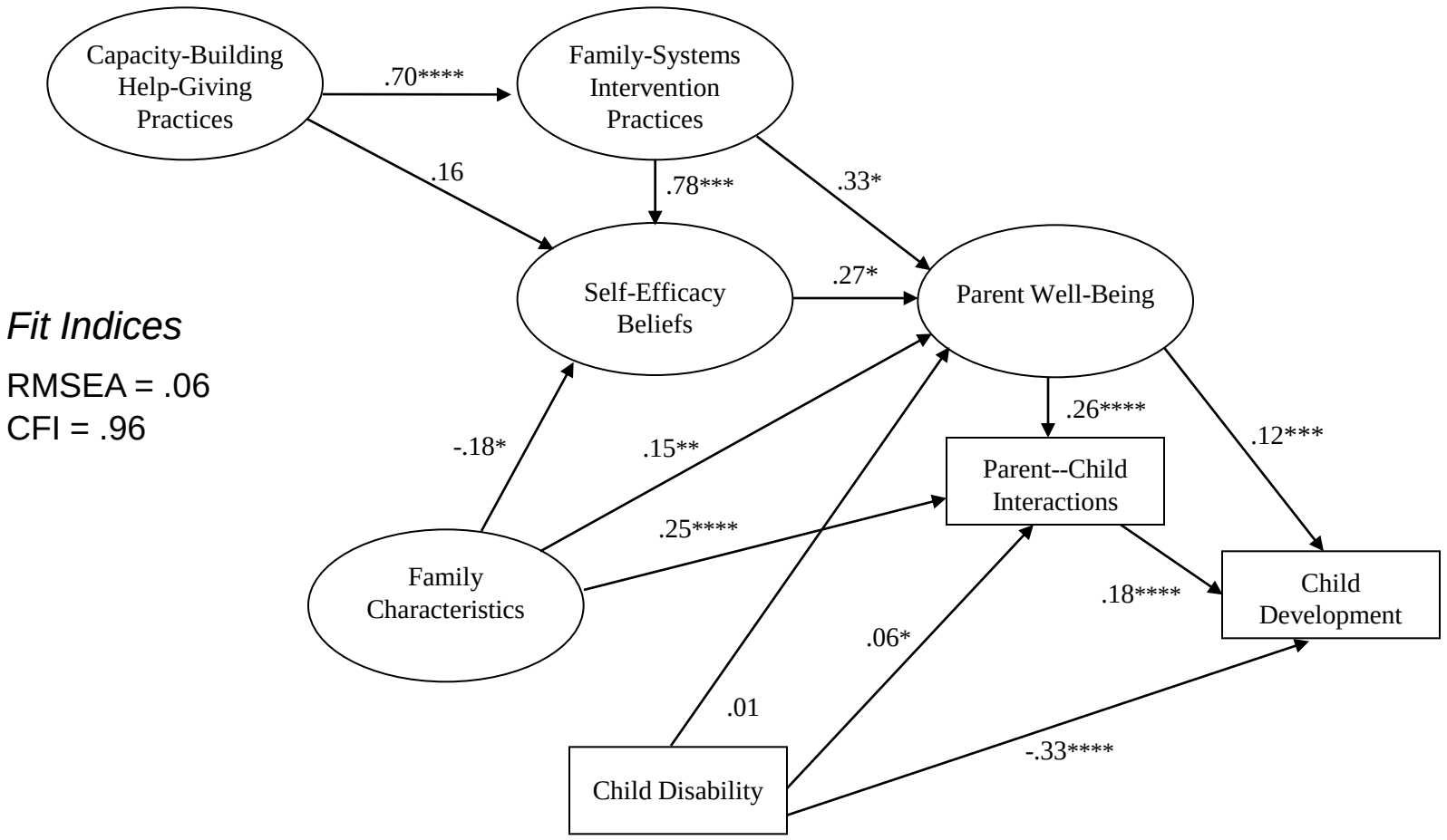


[a] Dunst, C.J., & Trivette, C.M., (2009). Capacity-building family-systems intervention practices. *Journal of Family Social Work*, 12, 119-143.

Model for Assessing the Direct and Indirect Effects of Different Predictor Variables on Parent-Child Interactions and Child Development



Meta-Analytic Structural Equation Modeling Results



Fit Indices

RMSEA = .06
CFI = .96

* p < .05. **p < .01. *** p < .001. **** p < .0001.

Influences of Nursery Rhyme Knowledge on Phonological Awareness and Later Reading Abilities[a]

Carl J. Dunst Carol M. Trivette

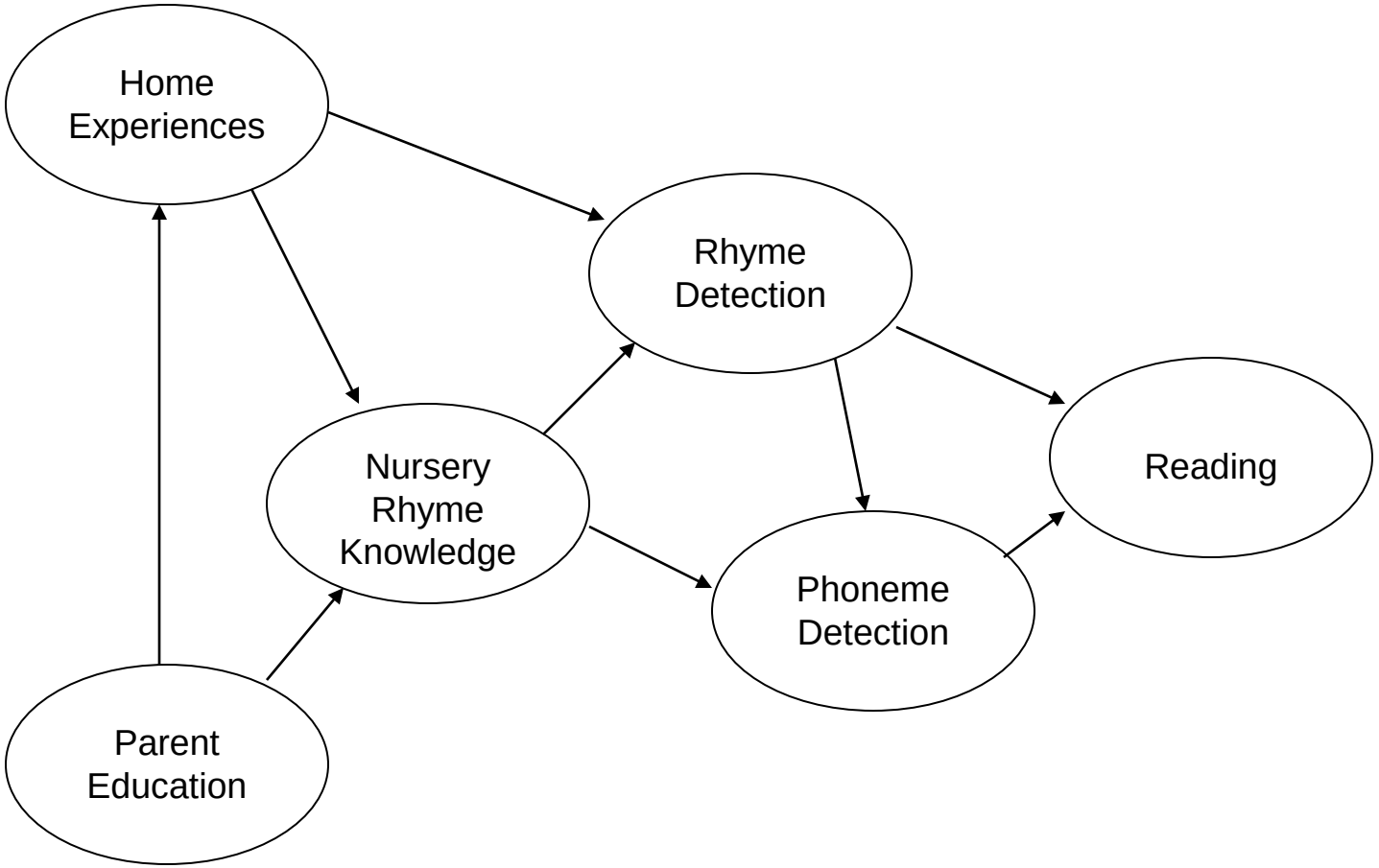
Studies: 12 studies (identified so far) that have assessed preschoolers nursery rhyme knowledge or awareness and its relationship to phonological awareness and later reading abilities

Sample: 300 + (so far)

Measures: Home experiences, nursery rhyme knowledge, phonological awareness (rhyme detection, phoneme detection), parent education, child IQ, reading, vocabulary, expressive language, and receptive language (among other measures)

[a] In preparation.

Model for Evaluating the Determinants and Consequences of Nursery Rhyme Knowledge[a]



[a] Based on research conducted by Peter Bryant, Lynette Bradley, and colleagues at the University of Oxford.

Conclusions

- Meta-analytic structural equation modeling is useful for evaluating the direct and indirect effects of different kinds of intervention practices on outcomes of interest

- One could include measured intervention variables in a MASEM model and evaluate their effects on outcomes mediated by other variables (e.g., self-efficacy beliefs)

- There are many different kinds of early childhood intervention studies that could be examined to determine the pathways of influence of different kinds of intervention practices on child, parent-child, and child outcomes