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

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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

• 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).

An Example of a Meta-Analysis Using Contrasts Effect Sizes
Meta-Analysis of the Effectiveness of Four Adult Learning Methods and Strategies

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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### Cohen’s d Effect Sizes for the Different Adult Learning Method Characteristics and Practices

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

* p. <01. ** p <.0001.
An Example of a Meta-Analysis of Correlation Effect Sizes
Meta-Analysis of Family-Centered Help-giving Practices Research

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

Family-Centered Practices: Relational and participatory help-giving 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

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

<table>
<thead>
<tr>
<th>Outcome Measures</th>
<th>Relational Helping Practices</th>
<th>Participatory Helping Practices</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Effect Size&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Sample Size</td>
<td>Effect Size</td>
</tr>
<tr>
<td><strong>Participant Satisfaction</strong></td>
<td></td>
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<tr>
<td>Satisfaction with Staff</td>
<td>601</td>
<td>4</td>
</tr>
<tr>
<td>Satisfaction with Program</td>
<td>1598</td>
<td>20</td>
</tr>
<tr>
<td><strong>Self Efficacy Beliefs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Practitioner Control</td>
<td>1368</td>
<td>10</td>
</tr>
<tr>
<td>Program Control</td>
<td>754</td>
<td>10</td>
</tr>
<tr>
<td>Life Events Control</td>
<td>675</td>
<td>12</td>
</tr>
<tr>
<td><strong>Program Resources</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parent/Child Supports</td>
<td>181</td>
<td>4</td>
</tr>
<tr>
<td>Program Helpfulness</td>
<td>252</td>
<td>2</td>
</tr>
<tr>
<td><strong>Child Behavior</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive Child Behavior</td>
<td>345</td>
<td>8</td>
</tr>
<tr>
<td>Negative Child Behavior</td>
<td>93</td>
<td>8</td>
</tr>
<tr>
<td>Behavioral Competence</td>
<td>252</td>
<td>3</td>
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<tr>
<td><strong>Well-Being</strong></td>
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<tr>
<td>Personal Well-Being</td>
<td>1543</td>
<td>26</td>
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<tr>
<td>Family Well-Being</td>
<td>245</td>
<td>4</td>
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<tr>
<td><strong>Parenting Behavior</strong></td>
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<td></td>
</tr>
<tr>
<td>Confidence</td>
<td>331</td>
<td>3</td>
</tr>
<tr>
<td>Competence</td>
<td>236</td>
<td>2</td>
</tr>
<tr>
<td>Enjoyment</td>
<td>331</td>
<td>3</td>
</tr>
</tbody>
</table>

*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

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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Path Diagram for the Relationships Among the Measures in the Model

Participatory Learning Opportunities

Child Outcomes

Parent Outcomes
Structural Equation Modeling Results

Comparative Fit Index = .97

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

Effects Decomposition
Direct = .13
Indirect = .53
Total = .66
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 to prepare and analyze data to perform a MASEM.

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Two-Stage Structural Equation Modeling

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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Stage 1A: Pooling Correlation Matrices

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.


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

- Relational
- Participatory

Help-Giving Practices

Self-Efficacy Beliefs

Parenting Behavior

- Confidence
- Competence
- Enjoyment
Meta-Analytic Structural Equation Modeling Results

Help-Giving Practices

Self-Efficacy Beliefs

Parenting Behavior

.00

.61 *

.33 *

Fit Indices

RMSEA = 0.05
CFI = 1.00

*p < .0001.
Multi-Variable Model Examples

• 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.

^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

Fit Indices

RMSEA = .04
CFI = 1.00

.89
.91
-0.07
.68***

Family-Centered Care

Relational
Participatory

.39***

Life Events Control Appraisals

Professional Control Appraisals

.97
-.55
-.06*
.29*

Parent Psychological Health

Positive
Negative

Child Special Health Care Needs Status

.61***

-.42
.51

Child Psychological Health

Positive
Negative

.11**
.21***
.15

*p < .01, **p < .001, ***p < .0001.
Influences of Family-Systems Intervention Practices on Parent-Child Interactions and Child Development

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

\footnotesize{\textcolor{red}{a} Topics in Early Childhood Special Education, 2010, 30, 3-19.}
Family-Systems Intervention Model

- Capacity-Building
- Help-Giving Practices
- Family Concerns and Priorities
- Family Strengths
- Supports and Resources

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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

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 Knowledgeª

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