AERA SRMA-SIG Online Seminar

Friday the 13th & Single Case Experimental Designs:

Allegedly Unlucky Encounters for Meta-Analysts

John Ferron, PhD & Megan Kirby, PhD
13 November 2024

Acknowledgements

Methods Guide for Effect Estimation and Synthesis of Single-Case Studies

January 16, 2024

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Disclaimer

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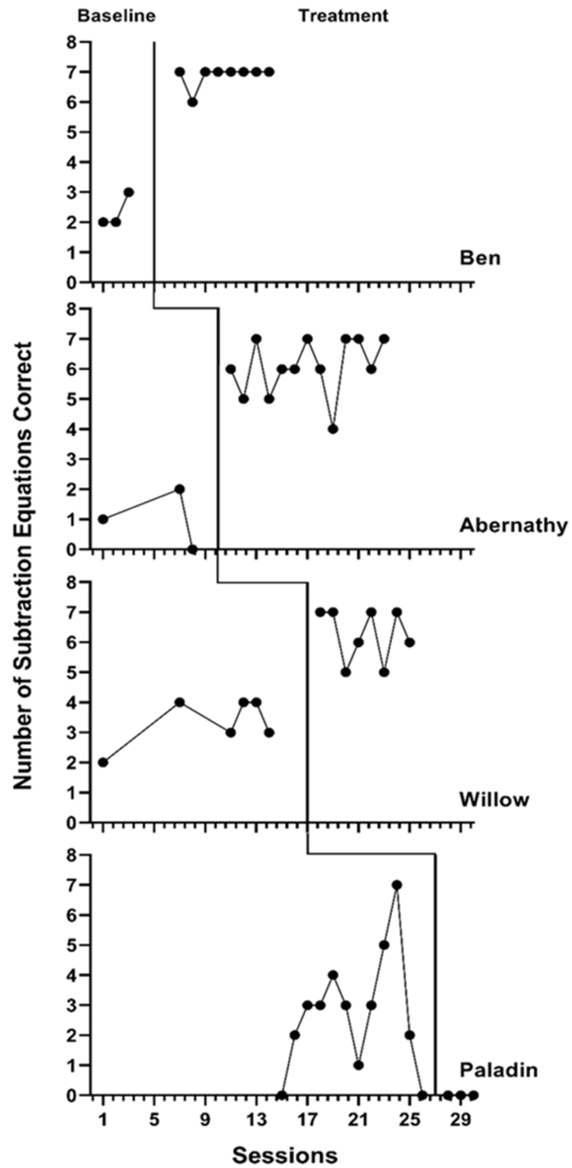
Single Case Experimental Designs



Used by:

Professionals & researchers
Education, psychology, organizational behavior management, medicine

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To study:

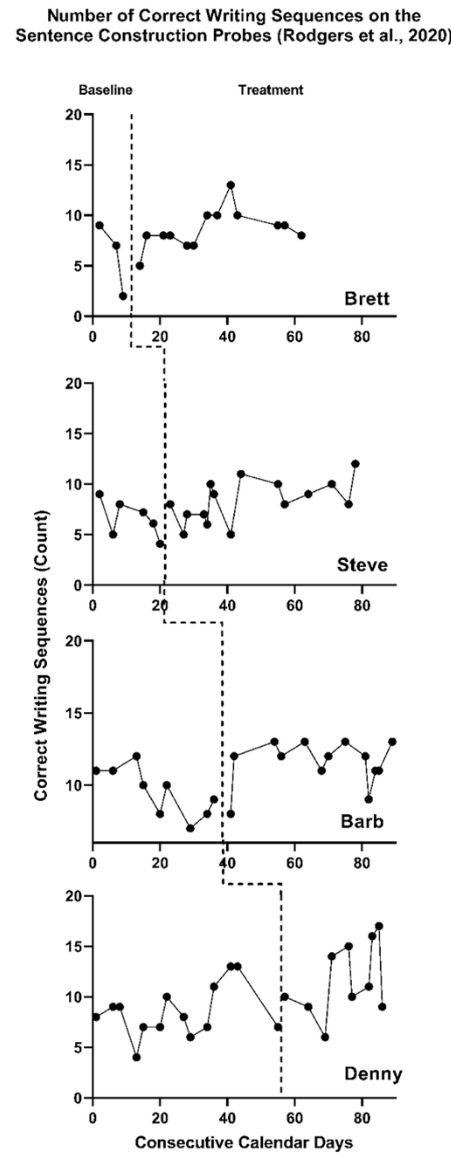
The effects of an intervention on an individual participant

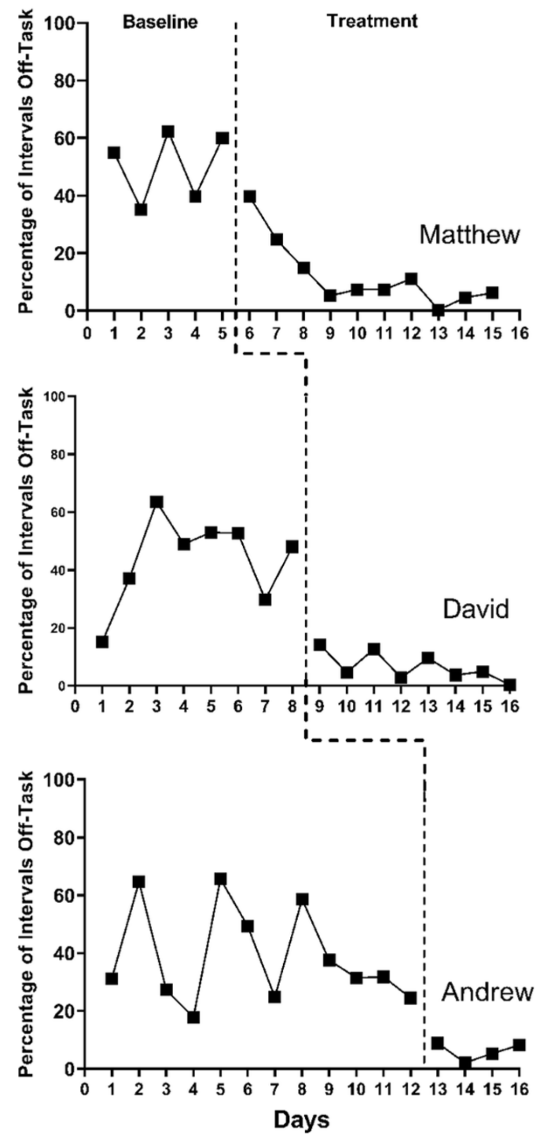
For:

Studying special populations
Developing new interventions
Practitioner led research
Focusing on individuals

Raw Participant Data

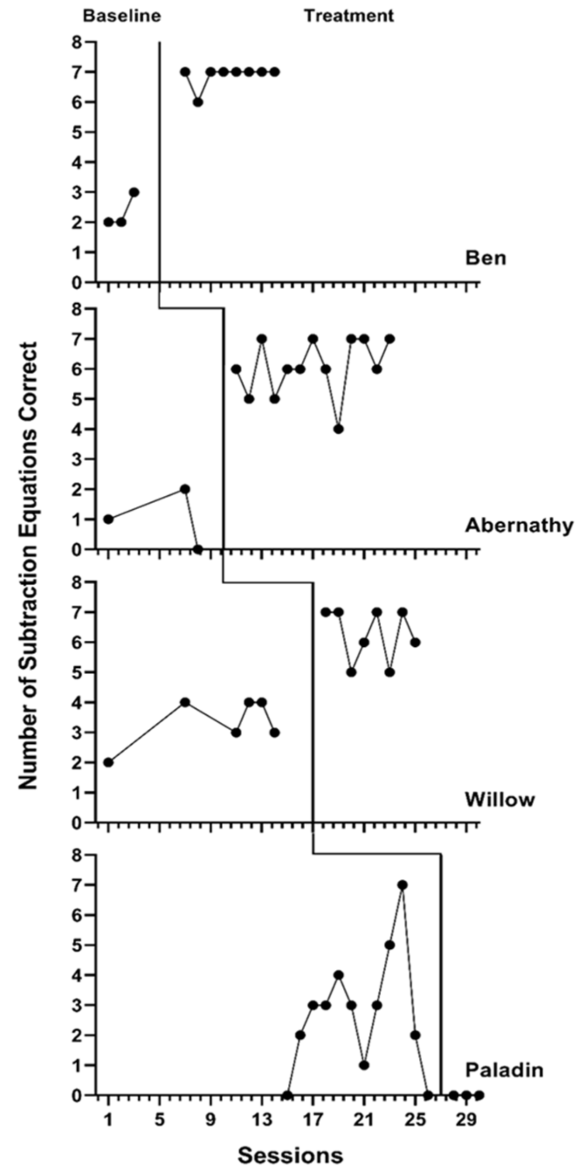
Individual cases
Common outcomes
Time





Graphical Analysis of Outcomes

Case, L. P., Harris, K. R., & Graham, S. (1992). Improving the mathematical problem-solving skills of students with learning disabilities: Self-regulated strategy development. The Journal of Special Education, 26, 1-19.



Dilemma in the Single Case Community

Are supplemental statistics necessary?

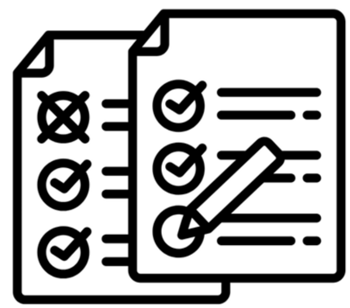
"We lose data about the individual when we summarize a graph with a single value."

"Why aren't they including our studies?"

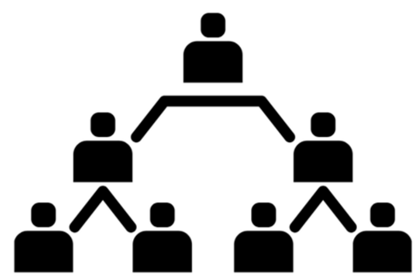
It's likely that a SCED study will not be eligible for inclusion in a meta-analysis if only visual analysis is conducted.

Choosing from 3 General Approaches

Design-Comparable Effect Sizes?

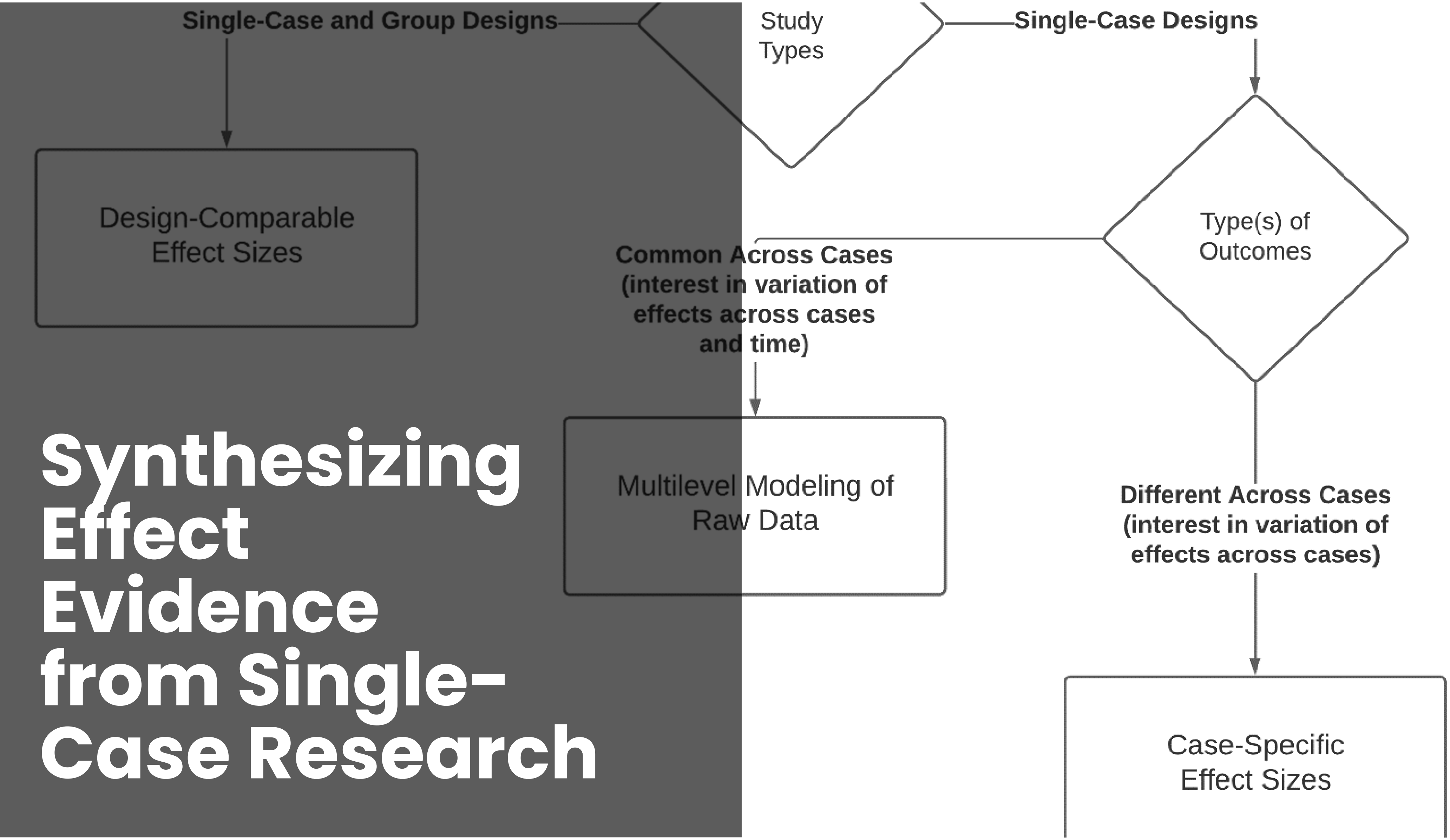


Case Specific Effect Sizes?
(e.g., NAP, TauU, SMDW, LRR, PoGO)



Multilevel Modeling?

Synthesizing Effect Evidence from Single-Case Research



Design-Comparable Effect Sizes

Choosing between the options for Between-Case Standardized Mean Differences

"What would the standardized mean difference effect size be if one could somehow perform a between-group randomized experiment based on the same population of participants, intervention protocol, and outcome measures?"

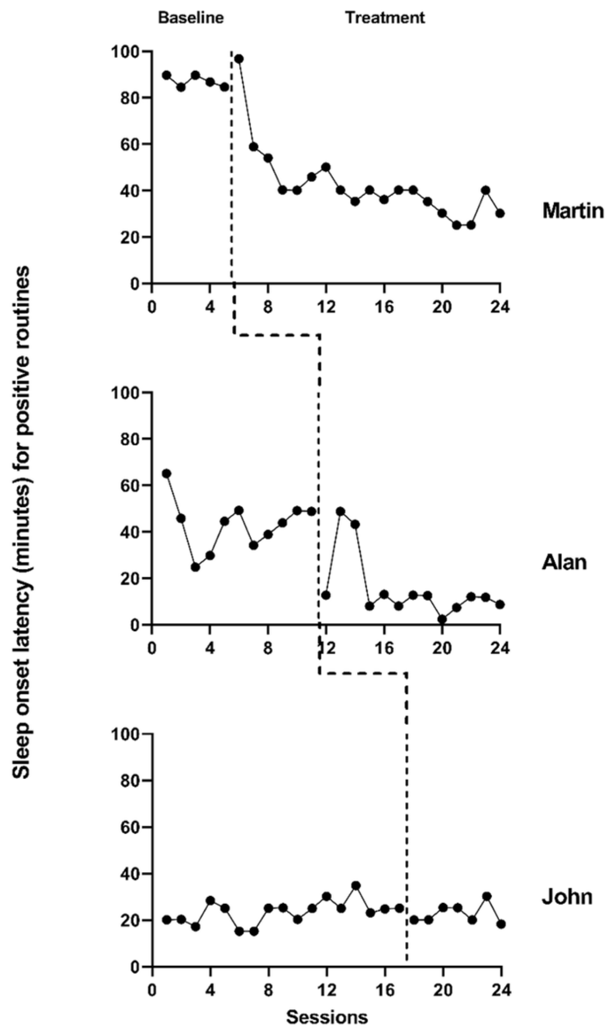
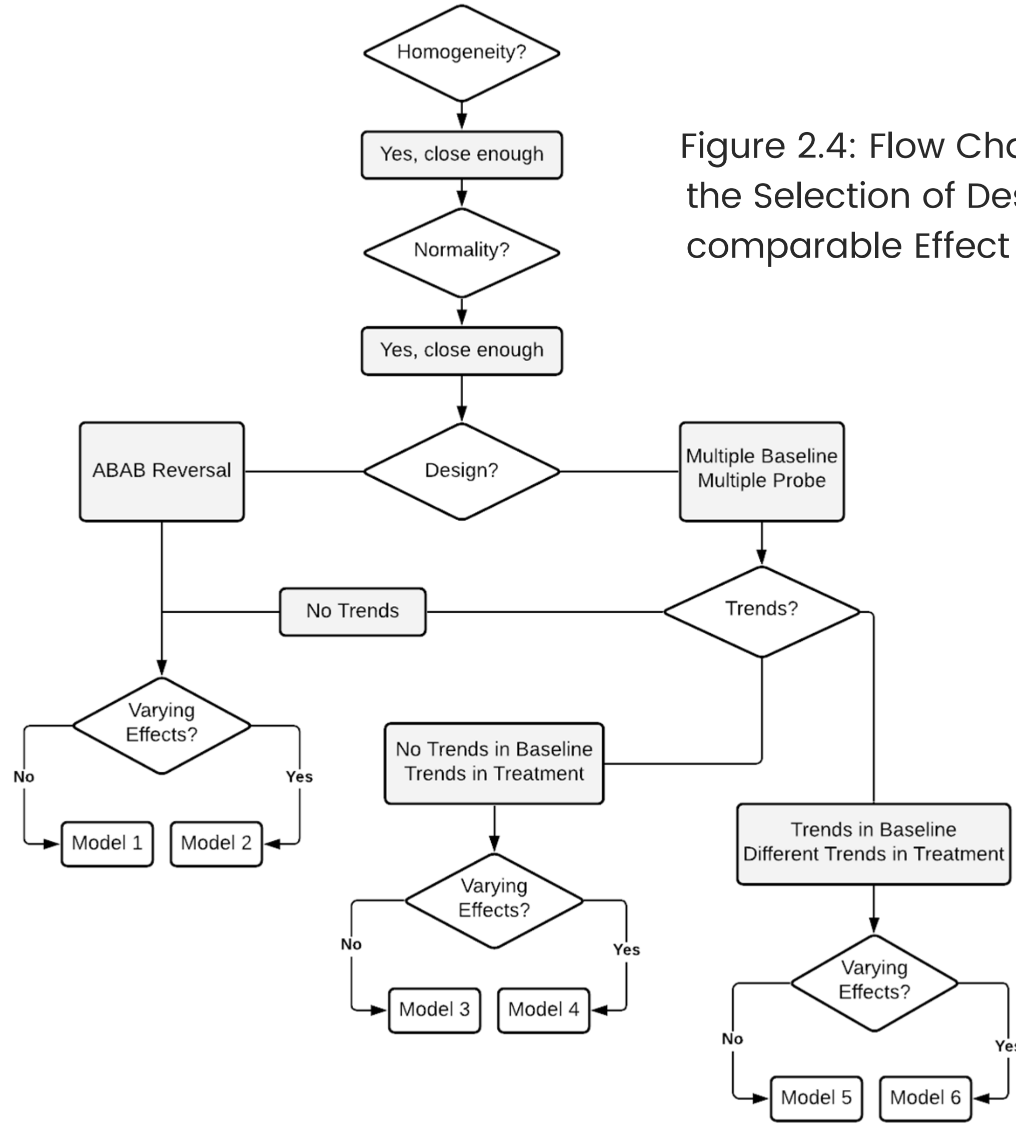


Figure 4.1: Multiple Baseline Data for Martin, Alan, and John (Delemere & Dounavi, 2018)

Figure 2.4: Flow Chart for the Selection of Design-comparable Effect Sizes



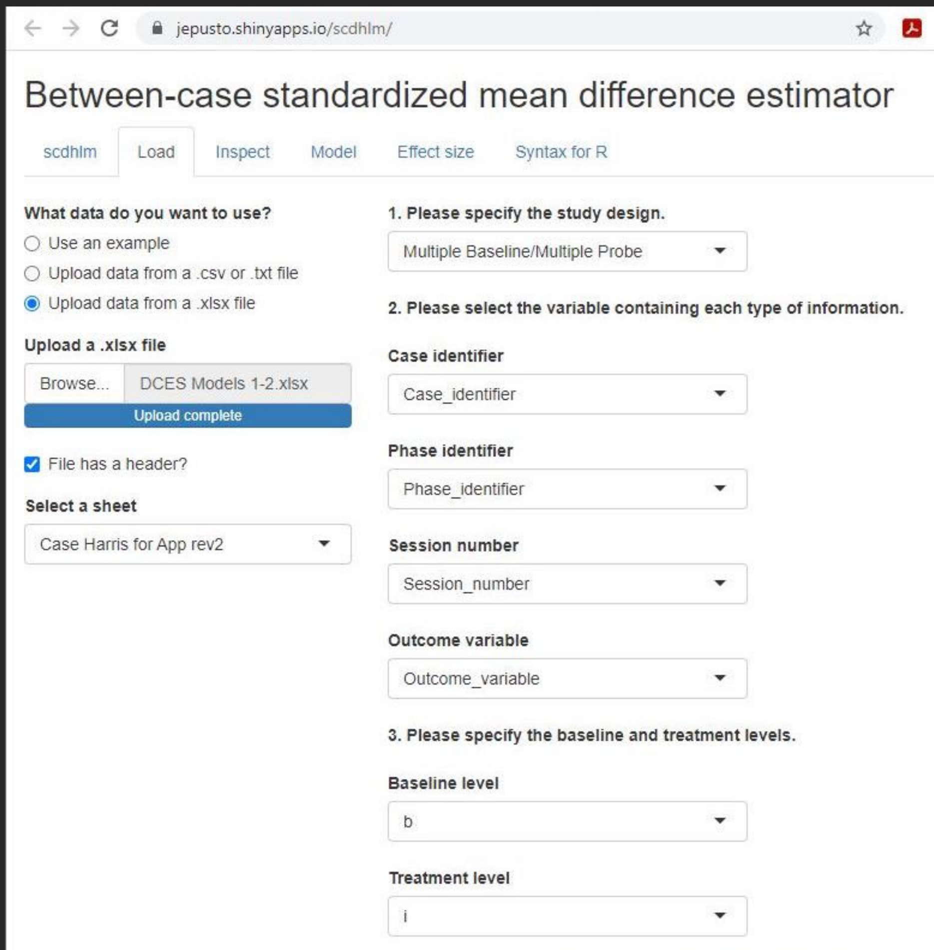
	A	B	C	D	E	F
1	Case iden	Phase ide	Session nu	Outcome variable		
2	Ben	b	1	2.0		
3	Ben	b	2	2.0		
4	Ben	b	3	3.0		
5	Ben	b	4			
6	Ben	b	5			
7	Ben	b	6			
8	Ben	i	7	7.0		
9	Ben	i	8	6.0		
10	Ben	i	9	7.0		
11	Ben	i	10	5.0		
12	Ben	i	11	7.0		
13	Ben	i	12	5.0		
14	Ben	i	13	6.0		
15	Ben	i	14	7.0		
16	Abernathy	b	1	1.0		
17	Abernathy	b	2			
18	Abernathy	b	3			
19	Abernathy	b	4			

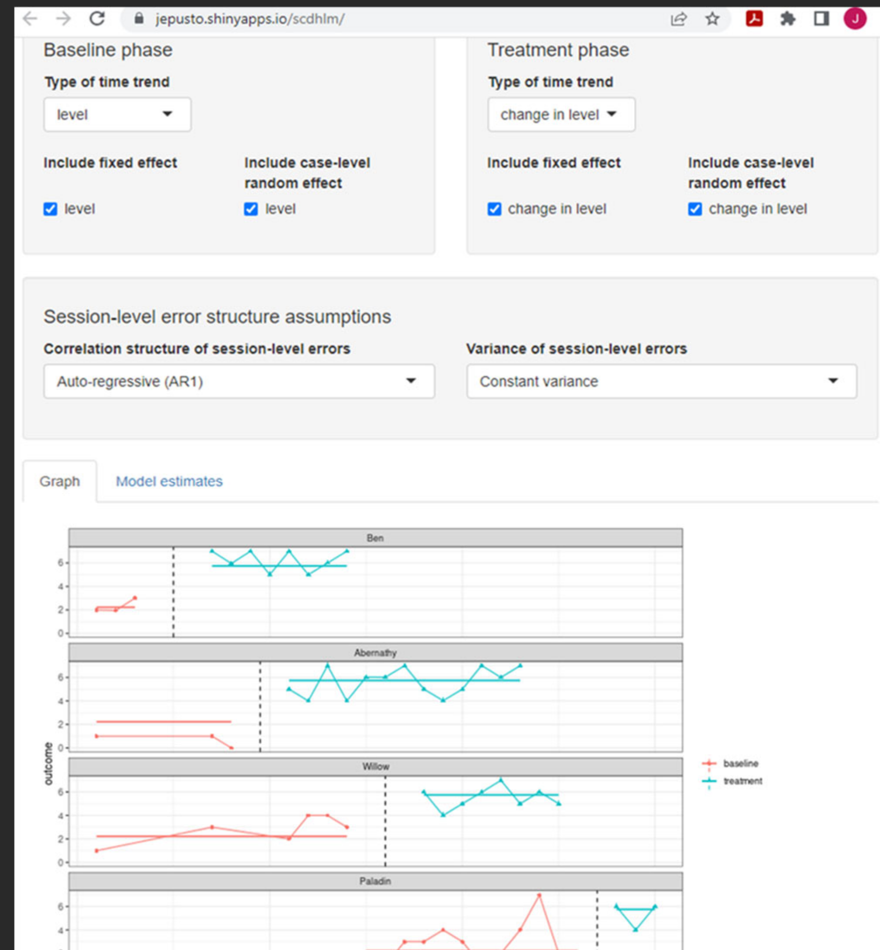
DCES Calculations

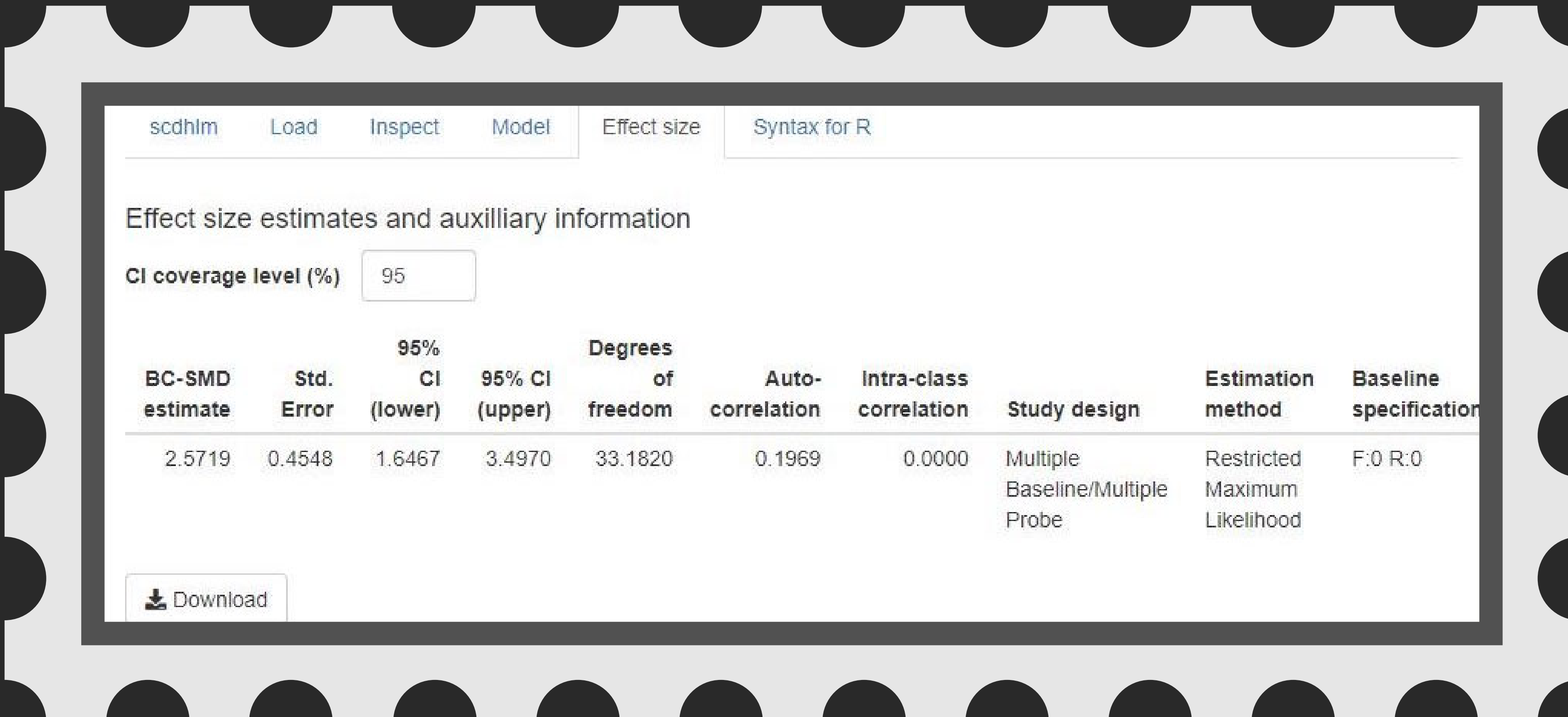
scdhlm application

https://jepusto.shinyapps.io/scdhlm/

(Pustejovsky et al., 2021)


jepusto.shinyapps.io/scdhlm/
Between-case standardized mean difference estimator
scdhlm
Load
Inspect
Model
Effect size
Syntax for R
What data do you want to use?
Use an example
Upload data from a .csv or .txt file
Upload data from a .xlsx file
Upload a .xlsx file
Browse...
DCES Models 1-2.xlsx
Upload complete
File has a header?
Select a sheet
Case Harris for App rev2
1. Please specify the study design.
Multiple Baseline/Multiple Probe
2. Please select the variable containing each type of information.
Case identifier
Case_identifier
Phase identifier
Phase_identifier
Session number
Session_number
Outcome variable
Outcome_variable
3. Please specify the baseline and treatment levels.
Baseline level
b
Treatment level
i


jepusto.shinyapps.io/scdhlm/
Baseline phase
Type of time trend
level
Include fixed effect
Include case-level random effect
level
level
Treatment phase
Type of time trend
change in level
Include fixed effect
Include case-level random effect
change in level
change in level
Session-level error structure assumptions
Correlation structure of session-level errors
Auto-regressive (AR1)
Variance of session-level errors
Constant variance
Graph
Model estimates
Ben
Abernathy
Willow
Paladin
outcome
baseline
treatment


scdhlm | Load | Inspect | Model | Effect size | Syntax for R

Effect size estimates and auxilliary information

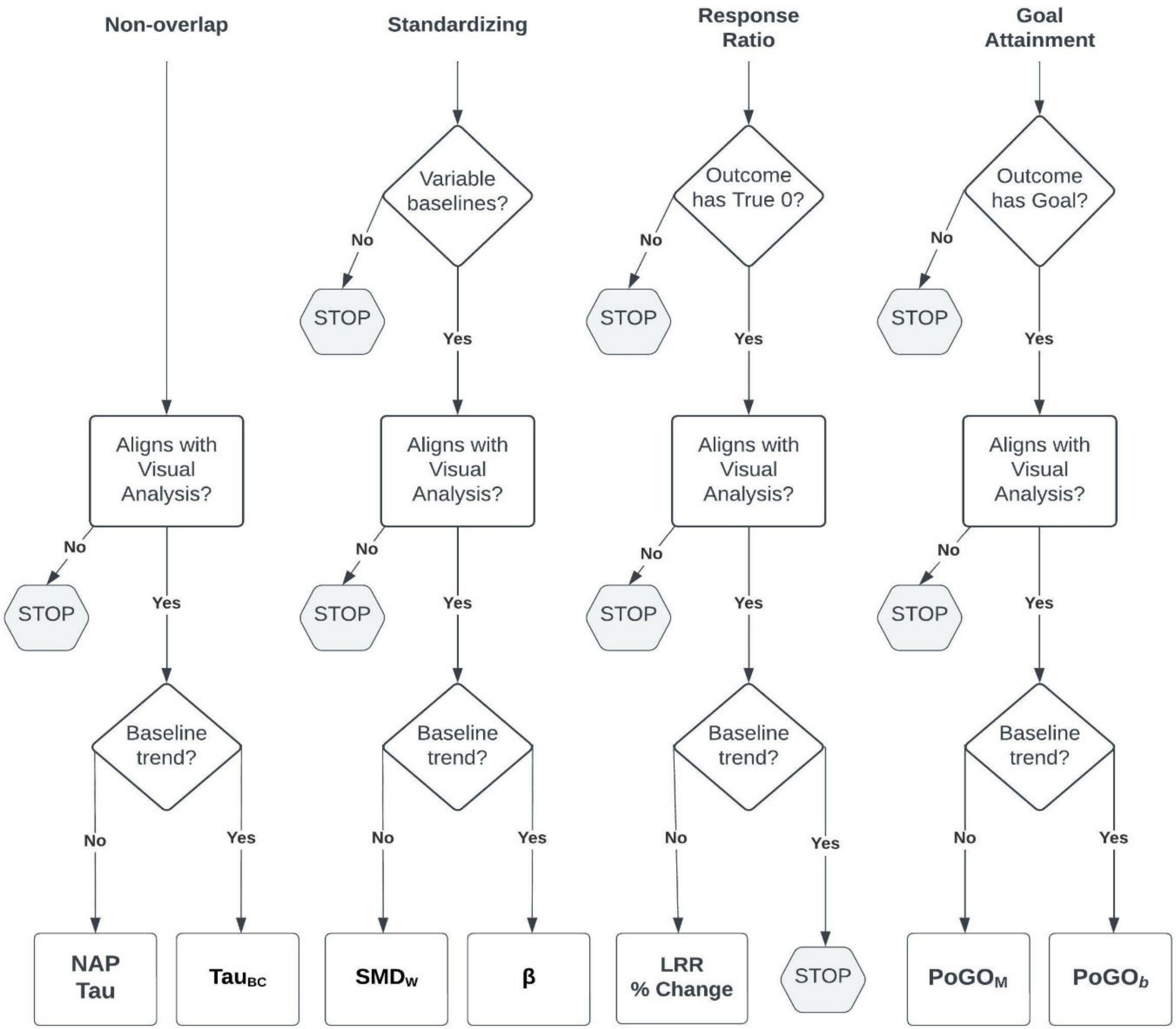
CI coverage level (%) 95

BC-SMD estimate	Std. Error	95% CI (lower)	95% CI (upper)	Degrees of freedom	Auto-correlation	Intra-class correlation	Study design	Estimation method	Baseline specification
2.5719	0.4548	1.6467	3.4970	33.1820	0.1969	0.0000	Multiple Baseline/Multiple Probe	Restricted Maximum Likelihood	F:0 R:0

Download

DCES Calculation

(scdhlm web-based app)



Case Specific Effect Sizes

Non-overlap

Standardizing

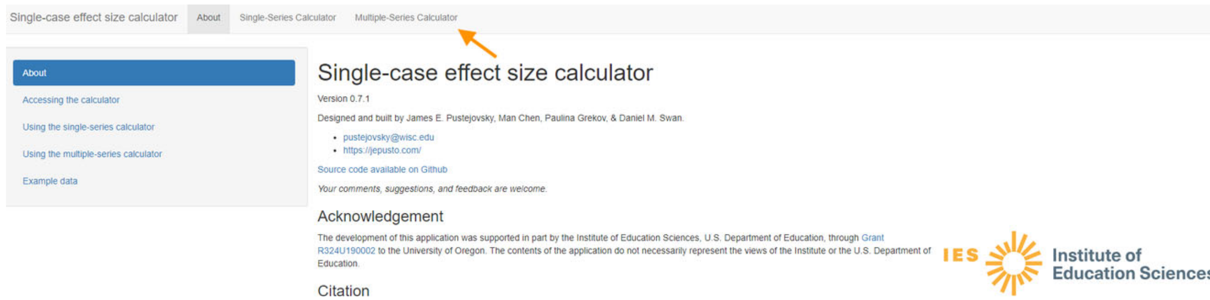
Response Ratio

Goal Attainment

Case Specific Effect Sizes

Concern	PND	PEM	ECL	NAP (Tau)	TauU	TauBC	SMD (g)	B	LRR	PoGO
Outliers	☹️	🙂	😐	🙂	😐	😐	😐	😐	🙂	😐
Baseline length	☹️	🙂	🙂	🙂	☹️	🙂	🙂	🙂	🙂	🙂
SE estimation*	☹️	☹️	☹️	😐	☹️	☹️	😐	😐	😐	😐
Baseline trends**	☹️	☹️	😐	☹️	😐	😐	☹️	😐	☹️	😐
Ceiling effects	☹️	☹️	☹️	☹️	☹️	☹️	🙂	🙂	🙂	🙂
Baselines of 0	🙂	🙂	🙂	🙂	🙂	🙂	☹️	☹️	☹️	🙂
Outcome scale: No true 0	🙂	🙂	🙂	🙂	🙂	🙂	🙂	🙂	☹️	🙂
Outcome has no goal	🙂	🙂	🙂	🙂	🙂	🙂	🙂	🙂	🙂	☹️
Computational accessibility	🙂	🙂	😐	🙂	🙂	🙂	🙂	😐	🙂	😐

*no smiles, because even those that have standard errors rely on tenuous assumptions
**no smiles, because even those that have trend adjustments rely on tenuous assumptions



Single-Case Effect Size Calculator (Pustejovsky et al., 2023)

Web-based app

https://jepusto.shinyapps.io/SCD-effect-sizes/

Video demonstration of the Single-Series Calculator: https://www.youtube.com/watch?v=V_r9MEX9LwY

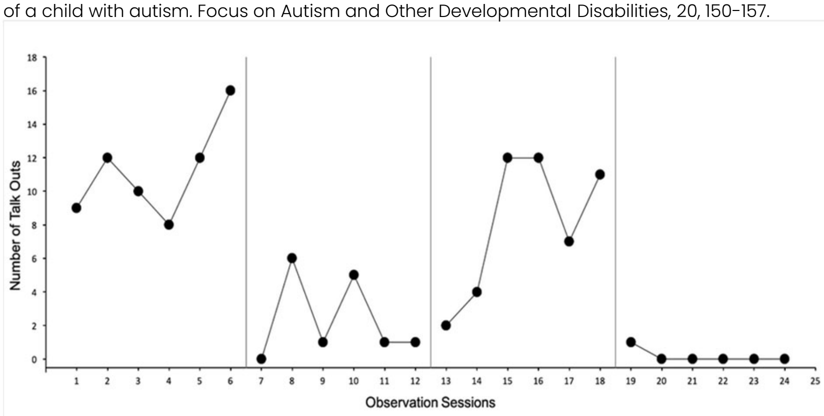
SingleCaseES R package

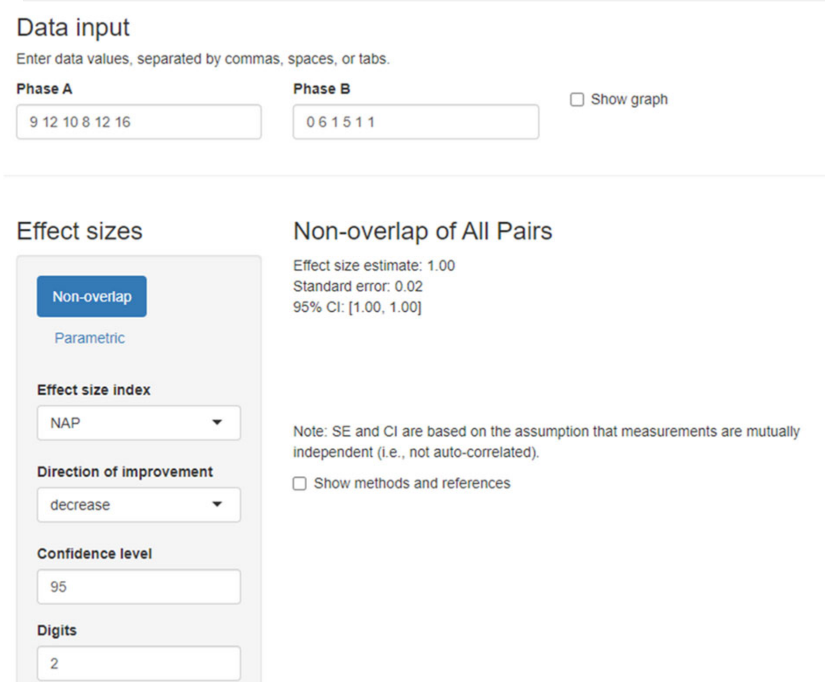
https://jepusto.github.io/SingleCaseES/

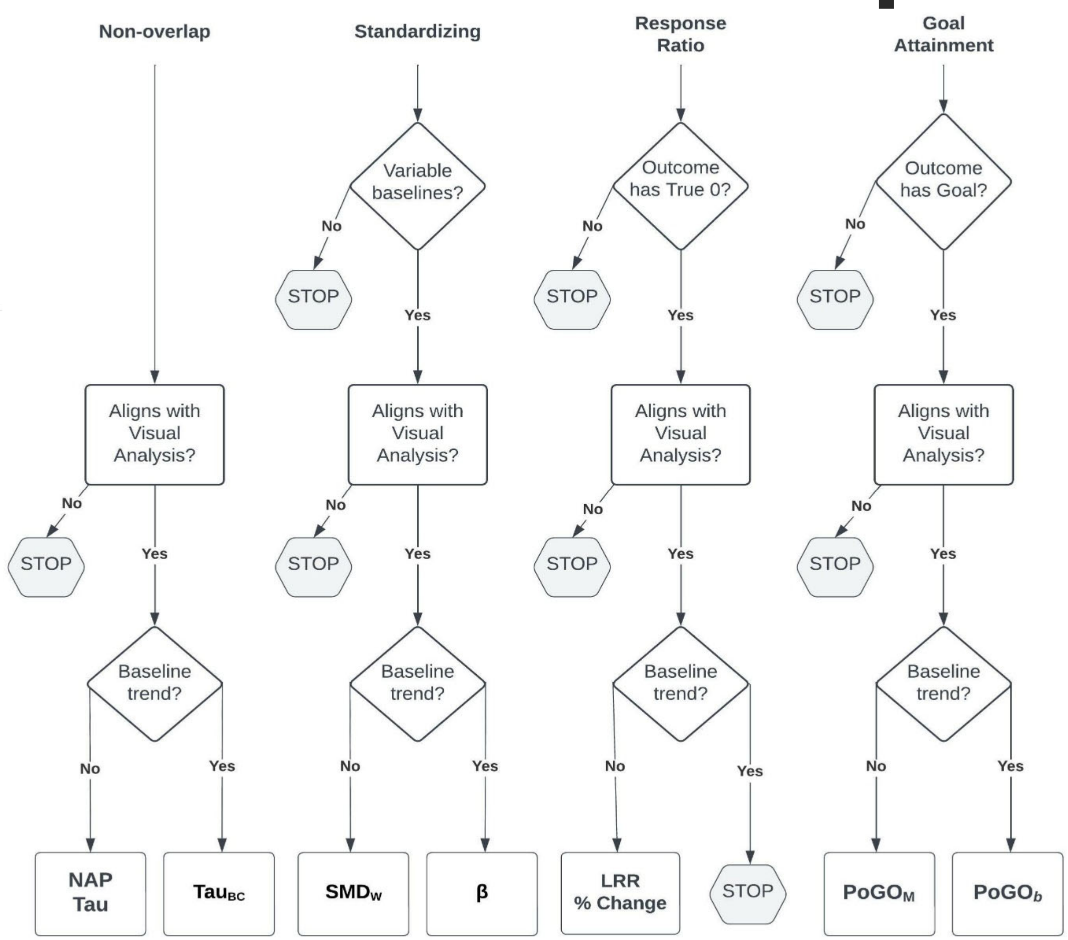
Video demonstration of the Multiple-Series Calculator: https://www.youtube.com/watch?v=DSW7wuFG7og

Illustrative Example

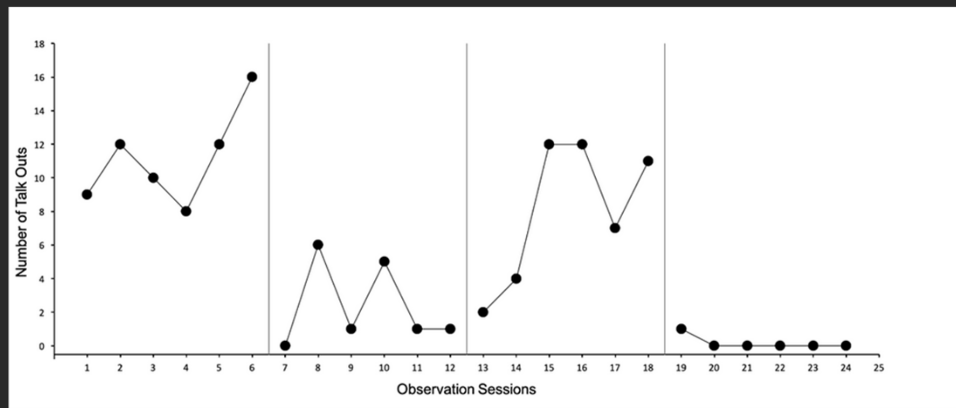
Crozier, S., & Tincani, M.J. (2005). Using a modified social story to decrease disruptive behavior of a child with autism. Focus on Autism and Other Developmental Disabilities, 20, 150-157.







Summary of Effect Sizes from Crozier & Tincani (2005)



Phase Change: A1 to B1	Phase Change: B1 to A2	Phase Change: A2 to B2
NAP = 1.00	NAP = .89	NAP = 1.00
SMDW = 2.60	SMDW = 1.91	SMDW = 1.52
LRR = −1.48	LRR = 1.16	LRR = −3.40
% Change = −77	% Change = 219	% Change = −97
PoGO = 79.1	PoGO = 64.2	PoGO = 97.9

Multilevel Modeling of Raw Data

Choosing between the options for multilevel models of SCED

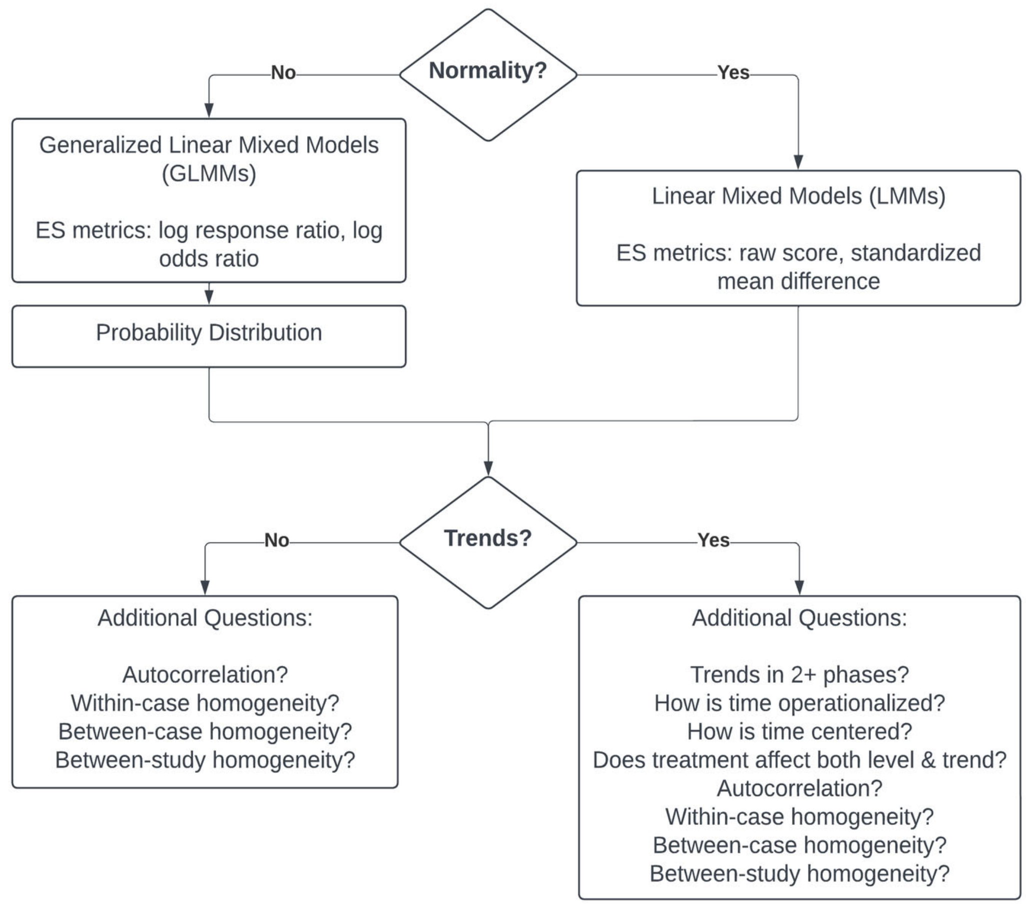


Figure 6.2: Flow Chart for the Selection of Multilevel Modeling Approach

Multilevel Modeling Options for Synthesis of SCED Studies

MultiSCED application
(Declercq et al., 2020)
http://34.251.13.245/MultiSCED

Your preferred application
R, SAS, etc.

Three-level model

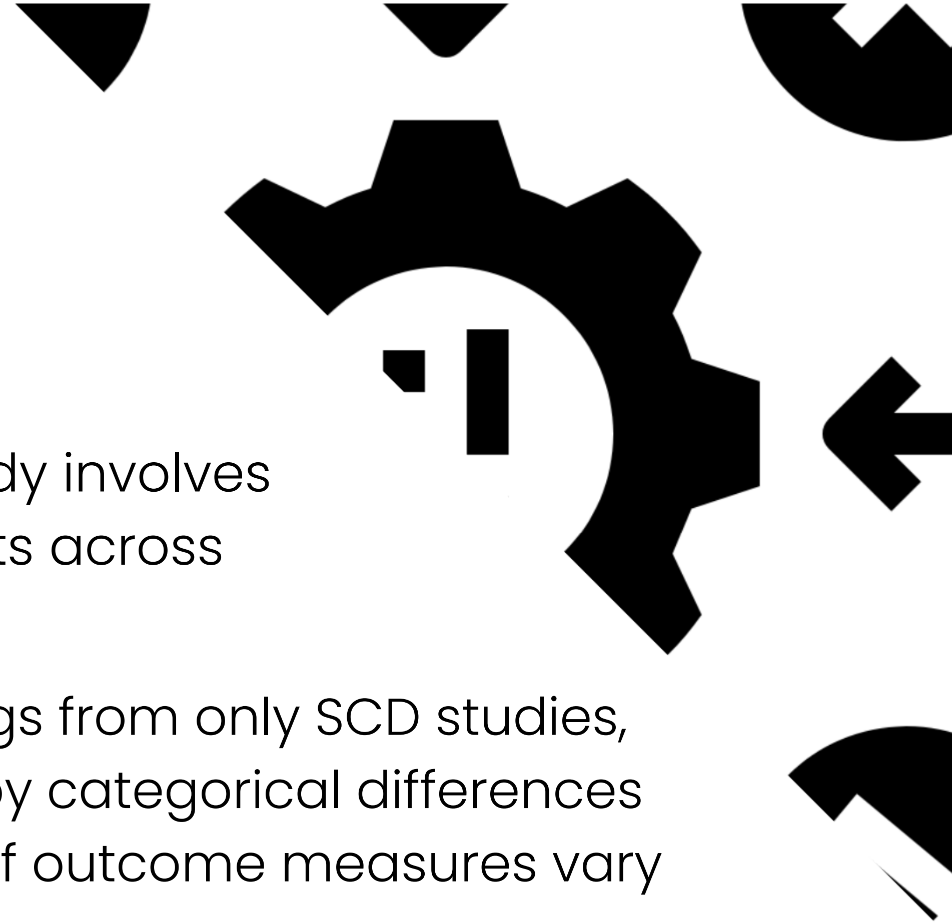
Used in the full meta-analysis.

$$\text{CWSpM}_{ijk} = \beta_0 + \beta_1 \text{Time}_{ijk} + \beta_2 \text{Intervention}_{ijk} + \beta_3 (\text{Intervention} \times \text{Time})_{ijk} + e_{ijk}$$

$$\begin{cases} \beta_{0jk} &= \theta_{00k} + u_{0jk} \\ \beta_{1jk} &= \theta_{10k} + u_{1jk} \\ \beta_{2jk} &= \theta_{20k} + u_{2jk} \\ \beta_{3jk} &= \theta_{30k} + u_{3jk} \end{cases}$$

$$\begin{cases} \theta_{00k} &= \gamma_{000} + v_{00k} \\ \theta_{10k} &= \gamma_{100} + v_{10k} \\ \theta_{20k} &= \gamma_{200} + v_{20k} \\ \theta_{30k} &= \gamma_{300} + v_{30k} \end{cases}$$

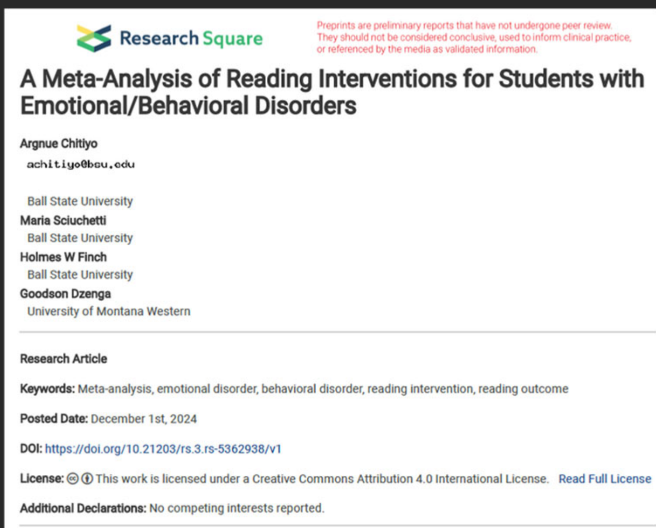
It’s all about context.



Design-Comparable: Purpose of the study involves the comparison and averaging of effects across single-case and group designs

Case Specific: Aim is to synthesize findings from only SCD studies, exploring variation in treatment effects by categorical differences or individual participant characteristics, If outcome measures vary across studies,

MLM: Analyzing a set of SCEDs that use very similar outcome measures, and the aim is to study effects over time within and between cases.


Research Square

Preprints are preliminary reports that have not undergone peer review. They should not be considered conclusive, used to inform clinical practice, or referenced by the media as validated information.

A Meta-Analysis of Reading Interventions for Students with Emotional/Behavioral Disorders

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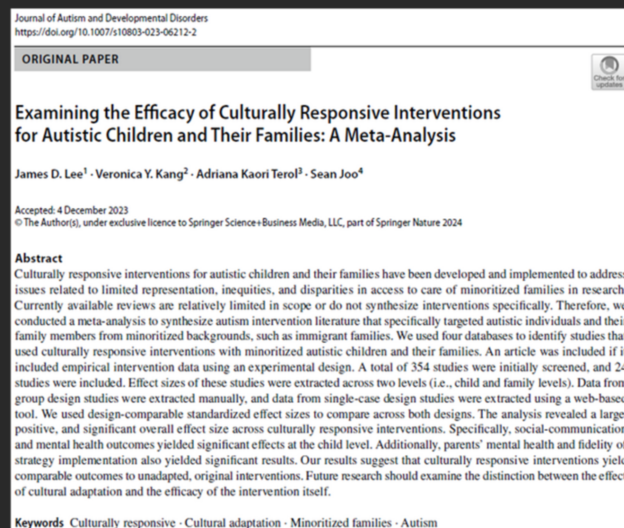
Research Article

Keywords: Meta-analysis, emotional disorder, behavioral disorder, reading intervention, reading outcome

Posted Date: December 1st, 2024

DOI: https://doi.org/10.21203/rs.3.rs-5362938/v1

Additional Declarations: No competing interests reported.


Journal of Autism and Developmental Disorders
https://doi.org/10.1007/s10803-023-06212-2

ORIGINAL PAPER

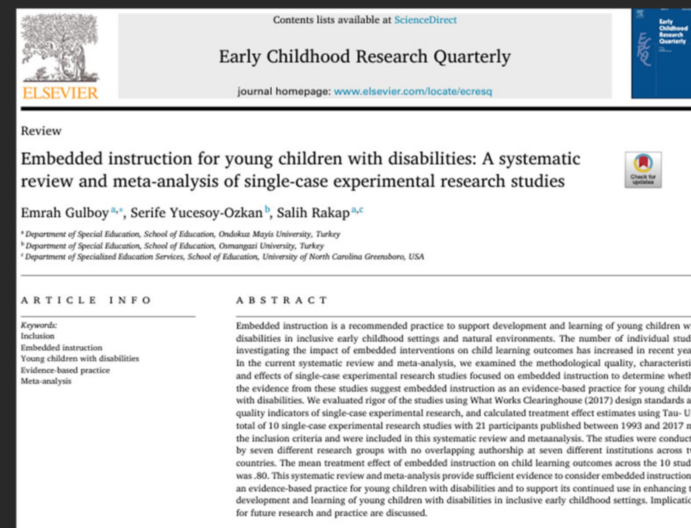
Examining the Efficacy of Culturally Responsive Interventions for Autistic Children and Their Families: A Meta-Analysis

James D. Lee[1] · Veronica Y. Kang[2] · Adriana Kaori Terol[3] · Sean Joo[4]

Accepted: 4 December 2023

Abstract
Culturally responsive interventions for autistic children and their families have been developed and implemented to address issues related to limited representation, inequities, and disparities in access to care of minoritized families in research. Currently available reviews are relatively limited in scope or do not synthesize interventions specifically. Therefore, we conducted a meta-analysis to synthesize autism intervention literature that specifically targeted autistic individuals and their family members from minoritized backgrounds, such as immigrant families. We used four databases to identify studies that used culturally responsive interventions with minoritized autistic children and their families. An article was included if it included empirical intervention data using an experimental design. A total of 354 studies were initially screened, and 24 studies were included. Effect sizes of these studies were extracted across two levels (i.e., child and family levels). Data from group design studies were extracted manually, and data from single-case design studies were extracted using a web-based tool. We used design-comparable standardized effect sizes to compare across both designs. The analysis revealed a large, positive, and significant overall effect size across culturally responsive interventions. Specifically, social-communication and mental health outcomes yielded significant effects at the child level. Additionally, parents' mental health and fidelity of strategy implementation also yielded significant results. Our results suggest that culturally responsive interventions yield comparable outcomes to unadapted, original interventions. Future research should examine the distinction between the effect of cultural adaptation and the efficacy of the intervention itself.

Keywords Culturally responsive · Cultural adaptation · Minoritized families · Autism


Contents lists available at ScienceDirect
Early Childhood Research Quarterly
journal homepage: www.elsevier.com/locate/ecresq

Review

Embedded instruction for young children with disabilities: A systematic review and meta-analysis of single-case experimental research studies

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ARTICLE INFO

Keywords:
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Embedded instruction
Young children with disabilities
Evidence-based practice
Meta-analysis

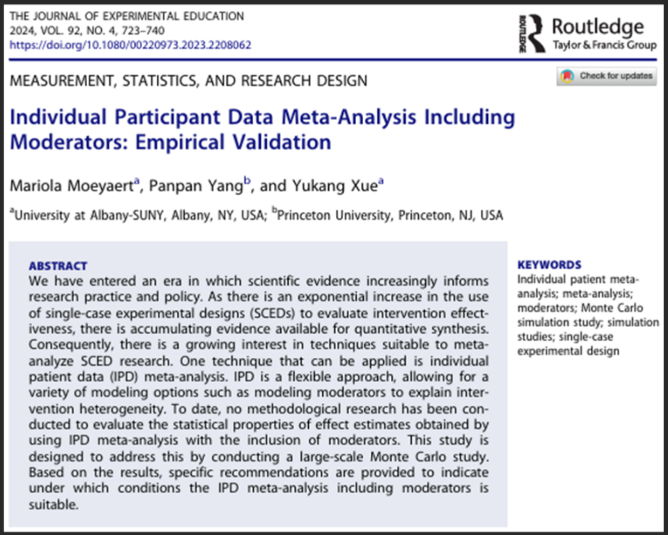
ABSTRACT

Embedded instruction is a recommended practice to support development and learning of young children with disabilities in inclusive early childhood settings and natural environments. The number of individual studies investigating the impact of embedded interventions on child learning outcomes has increased in recent years. In the current systematic review and meta-analysis, we examined the methodological quality, characteristics, and effects of single-case experimental research studies focused on embedded instruction to determine whether the evidence from these studies suggest embedded instruction as an evidence-based practice for young children with disabilities. We evaluated rigor of the studies using What Works Clearinghouse (2017) design standards and quality indicators of single-case experimental research, and calculated treatment effect estimates using Tau- U. A total of 10 single-case experimental research studies with 21 participants published between 1993 and 2017 met the inclusion criteria and were included in this systematic review and metaanalysis. The studies were conducted by seven different research groups with no overlapping authorship at seven different institutions across two countries. The mean treatment effect of embedded instruction on child learning outcomes across the 10 studies was .80. This systematic review and meta-analysis provide sufficient evidence to consider embedded instruction as an evidence-based practice for young children with disabilities and to support its continued use in enhancing the development and learning of young children with disabilities in inclusive early childhood settings. Implications for future research and practice are discussed.

Some Concrete Examples

Recent syntheses using DCES and Case Specific effect size estimation methods

MLM Examples



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Routledge
Taylor & Francis Group

MEASUREMENT, STATISTICS, AND RESEARCH DESIGN

Check for updates

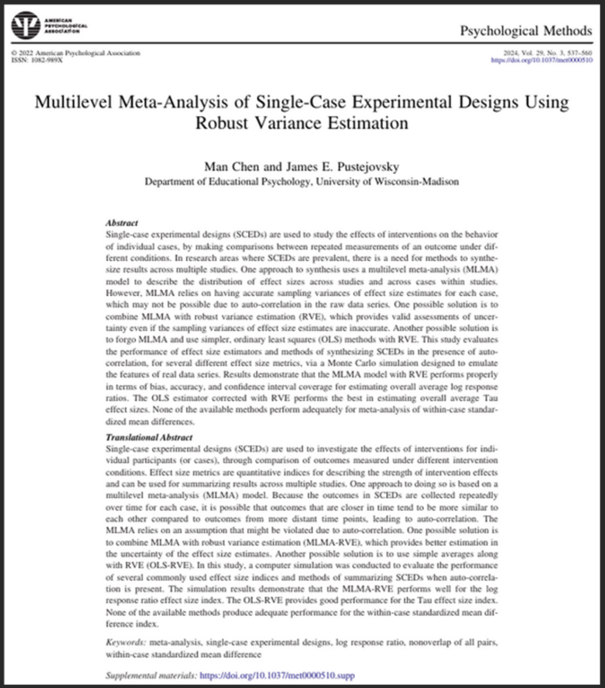
Individual Participant Data Meta-Analysis Including Moderators: Empirical Validation

Mariola Moeyaert[a], Panpan Yang[b], and Yukang Xue[a]

[a]University at Albany-SUNY, Albany, NY, USA; [b]Princeton University, Princeton, NJ, USA

ABSTRACT
We have entered an era in which scientific evidence increasingly informs research practice and policy. As there is an exponential increase in the use of single-case experimental designs (SCEDs) to evaluate intervention effectiveness, there is accumulating evidence available for quantitative synthesis. Consequently, there is a growing interest in techniques suitable to meta-analyze SCED research. One technique that can be applied is individual patient data (IPD) meta-analysis. IPD is a flexible approach, allowing for a variety of modeling options such as modeling moderators to explain intervention heterogeneity. To date, no methodological research has been conducted to evaluate the statistical properties of effect estimates obtained by using IPD meta-analysis with the inclusion of moderators. This study is designed to address this by conducting a large-scale Monte Carlo study. Based on the results, specific recommendations are provided to indicate under which conditions the IPD meta-analysis including moderators is suitable.

KEYWORDS
Individual patient meta-analysis; meta-analysis; moderators; Monte Carlo simulation study; simulation studies; single-case experimental design



Psychological Methods

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2024, Vol. 29, No. 3, 537–560
https://doi.org/10.1037/met0000510

Multilevel Meta-Analysis of Single-Case Experimental Designs Using Robust Variance Estimation

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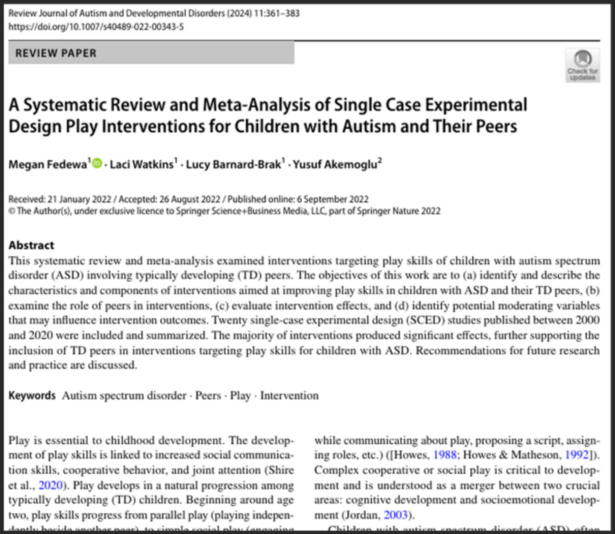
Abstract
Single-case experimental designs (SCEDs) are used to study the effects of interventions on the behavior of individual cases, by making comparisons between repeated measurements of an outcome under different conditions. In research areas where SCEDs are prevalent, there is a need for methods to synthesize results across multiple studies. One approach to synthesis uses a multilevel meta-analysis (MLMA) model to describe the distribution of effect sizes across studies and across cases within studies. However, MLMA relies on having accurate sampling variances of effect size estimates for each case, which may not be possible due to auto-correlation in the raw data series. One possible solution is to combine MLMA with robust variance estimation (RVE), which provides valid assessments of uncertainty even if the sampling variances of effect size estimates are inaccurate. Another possible solution is to forgo MLMA and use simpler, ordinary least squares (OLS) methods with RVE. This study evaluates the performance of effect size estimators and methods of synthesizing SCEDs in the presence of auto-correlation, for several different effect size metrics, via a Monte Carlo simulation designed to emulate the features of real data series. Results demonstrate that the MLMA model with RVE performs properly in terms of bias, accuracy, and confidence interval coverage for estimating overall average log response ratios. The OLS estimator corrected with RVE performs the best in estimating overall average Tau effect sizes. None of the available methods perform adequately for meta-analysis of within-case standardized mean differences.

Translational Abstract
Single-case experimental designs (SCEDs) are used to investigate the effects of interventions for individual participants (or cases), through comparison of outcomes measured under different intervention conditions. Effect size metrics are quantitative indices for describing the strength of intervention effects and can be used for summarizing results across multiple studies. One approach to doing so is based on a multilevel meta-analysis (MLMA) model. Because the outcomes in SCEDs are collected repeatedly over time for each case, it is possible that outcomes that are closer in time tend to be more similar to each other compared to outcomes from more distant time points, leading to auto-correlation. The MLMA relies on an assumption that might be violated due to auto-correlation. One possible solution is to combine MLMA with robust variance estimation (MLMA-RVE), which provides better estimation in the uncertainty of the effect size estimates. Another possible solution is to use simple averages along with RVE (OLS-RVE). In this study, a computer simulation was conducted to evaluate the performance of several commonly used effect size indices and methods of summarizing SCEDs when auto-correlation is present. The simulation results demonstrate that the MLMA-RVE performs well for the log response ratio effect size index. The OLS-RVE provides good performance for the Tau effect size index. None of the available methods produce adequate performance for the within-case standardized mean difference index.

Keywords: meta-analysis, single-case experimental designs, log response ratio, nonoverlap of all pairs, within-case standardized mean difference

Supplemental materials: https://doi.org/10.1037/met0000510.supp



Review Journal of Autism and Developmental Disorders (2024) 11:361–383
https://doi.org/10.1007/s40489-022-00343-5

REVIEW PAPER

Check for updates

A Systematic Review and Meta-Analysis of Single Case Experimental Design Play Interventions for Children with Autism and Their Peers

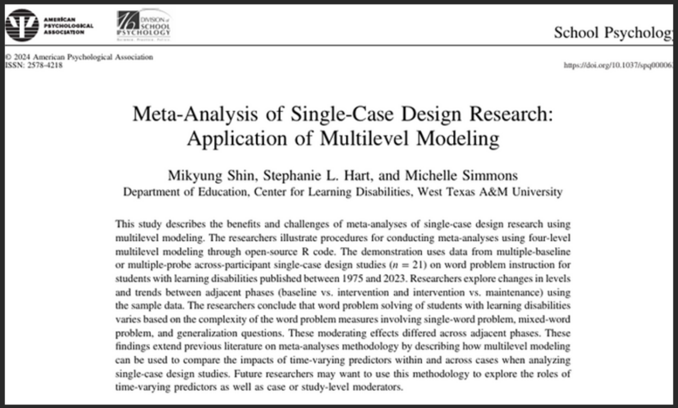
Megan Fedewa[1] · Laci Watkins[1] · Lucy Barnard-Brak[1] · Yusuf Akemoglu[2]

Received: 21 January 2022 / Accepted: 26 August 2022 / Published online: 6 September 2022

Abstract
This systematic review and meta-analysis examined interventions targeting play skills of children with autism spectrum disorder (ASD) involving typically developing (TD) peers. The objectives of this work are to (a) identify and describe the characteristics and components of interventions aimed at improving play skills in children with ASD and their TD peers, (b) examine the role of peers in interventions, (c) evaluate intervention effects, and (d) identify potential moderating variables that may influence intervention outcomes. Twenty single-case experimental design (SCED) studies published between 2000 and 2020 were included and summarized. The majority of interventions produced significant effects, further supporting the inclusion of TD peers in interventions targeting play skills for children with ASD. Recommendations for future research and practice are discussed.

Keywords Autism spectrum disorder · Peers · Play · Intervention

Play is essential to childhood development. The development of play skills is linked to increased social communication skills, cooperative behavior, and joint attention (Shire et al., 2020). Play develops in a natural progression among typically developing (TD) children. Beginning around age two, play skills progress from parallel play (playing independently beside another peer) to simple social play (engaging while communicating about play, proposing a script, assigning roles, etc.) ([Howes, 1988; Howes & Matheson, 1992]). Complex cooperative or social play is critical to development and is understood as a merger between two crucial areas: cognitive development and socioemotional development (Jordan, 2003).



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Meta-Analysis of Single-Case Design Research: Application of Multilevel Modeling

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This study describes the benefits and challenges of meta-analyses of single-case design research using multilevel modeling. The researchers illustrate procedures for conducting meta-analyses using four-level multilevel modeling through open-source R code. The demonstration uses data from multiple-baseline or multiple-probe across-participant single-case design studies ($n = 21$) on word problem instruction for students with learning disabilities published between 1975 and 2023. Researchers explore changes in levels and trends between adjacent phases (baseline vs. intervention and intervention vs. maintenance) using the sample data. The researchers conclude that word problem solving of students with learning disabilities varies based on the complexity of the word problem measures involving single-word problem, mixed-word problem, and generalization questions. These moderating effects differed across adjacent phases. These findings extend previous literature on meta-analyses methodology by describing how multilevel modeling can be used to compare the impacts of time-varying predictors within and across cases when analyzing single-case design studies. Future researchers may want to use this methodology to explore the roles of time-varying predictors as well as case or study-level moderators.

Thank you!

Questions?
Comments?

Methods Guide for Effect Estimation and Synthesis of Single-Case Studies

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Visit: https://jepusto.github.io/SCD-Methods-Guide/