Meta-analysis of single-case research: A brief and breezy tour

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Outline

1. Single-case research

2. Three approaches to meta-analysis of single-case designs.

3. Outstanding problems, areas to contribute
A community of researchers

Will Shadish
Wim van den Noortgate
Tasha Beretvas

David Rindskopf
Patrick Onghena

John Ferron
Swami

Mariola Moeyaert

Rob Horner
Larry Hedges

Dan Maggin
Single-case research

• Useful for understanding effects of interventions / practices for individuals across a variety of settings.
  • Frequently used in special education to study treatments for individuals with low-incidence disabilities.
  • In school psychology, students with behavioral disorders.
  • Growing interest within counseling psychology too.
  • N-of-1 trials used in medical/behavioral health research

• Essential features of single-case designs
  • One or small number of cases (individuals or groups)
  • Repeated measurement of outcomes on each individual case
  • Researcher-controlled introduction (& possibly removal) of an intervention for each case
Wright & McCurdy (2011). Class-wide positive behavior support and group contingencies: Examining a positive variation of the Good Behavior Game

Figure 1. Percentage of intervals showing disruptive and on-task behaviors in a kindergarten classroom.
Rodriguez & Anderson (2014). Integrating a social behavior intervention during small group academic instruction using a total group criterion intervention.
Why synthesize single-case studies?

1. Establish evidence-based practices in areas where SCDs are predominant.

2. Draw generalizations from collections of small studies.

3. Understanding *variation in* and *predictors of* treatment effectiveness (individual-participant data!)

4. Monitor and provide feedback about methodological quality, potential problems, areas where further research is needed.
3 broad approaches to synthesis of single-case designs (Pustejovsky & Ferron, 2017)

1. Meta-analysis of case-level effect size estimates
2. Meta-analysis of raw data
3. Meta-analysis of study-level effect size estimates
Case-level effect sizes

- Non-overlap measures
  - Percentage of non-overlapping data (PND; Scruggs et al., 1987)
  - Percentage exceeding the median (PEM; Ma, 2006)
  - Non-overlap of all pairs (Parker & Vannest, 2009)
  - Others: PAND, RIRD, Tau-U,…

- Magnitude of many non-overlap measures influenced by sample size (Pustejovsky, 2018a).

- Within-case standardized mean differences (Busk & Serlin, 1992)

- Ratio/log-ratio measures (Pustejovsky, 2015, 2018b)
  - Useful for count/proportion outcomes

- Shiny app: https://jepusto.shinyapps.io/SCD-effect-sizes/
Meta-analysis of case-level effect sizes

The strategy:

• Estimate a summary effect size index for each case in each study.
  • Direction & magnitude of treatment effect.

• Multi-level meta-analysis of effect size estimates (Van den Noortgate & Onghena, 2008; Ugille et al., 2012):

\[ T_{ij} = X_{ij} \beta + u_j + v_{ij} + e_{ij} \]

• Random effects describing within- and between-study variation in effects.
Meta-analysis of raw data

The strategy:

• Organize the raw data from all included studies & cases.

• Fit a multi-level model directly to the data (Van den Noortgate & Onghena, 2008; Moeyaert et al., 2013, 2014):

\[ Y_{hij} = \beta_{0ij} + Trt_{ij} \beta_{1ij} + e_{hij} \]

\[ \beta_{0ij} = \gamma_{0} + u_{0j} + v_{0ij} \]

\[ \beta_{1ij} = \gamma_{1} + u_{1j} + v_{1ij} \]

• Allows you to study within- and between-study variation in baseline levels and treatment effects.

• Ideal when studies use a common approach to outcome measurement.
Study-level effect size estimates

• Shadish, Rindskopf, & Hedges (2008) asked:

  *Can we estimate an effect size based on the data from a single-case design that is in the same metric as the standardized mean difference effect size from a between-groups design?*

• Why do this? (Shadish, Hedges, Horner, & Odom, 2015)
  • Translation of single-case research for researchers who work primarily with between-groups designs.
  • Comparison of results from single-case studies and between-groups studies, for purposes of understanding the utility and limitations of each type of design.
  • Synthesis involving both single-case and between-groups designs.
Study-level effect size estimates

  • Shiny app: https://jepusto.shinyapps.io/scdhlm/

• Study-level effect size estimates can be meta-analyzed using conventional methods.

• Limitations
  • Only available for certain types of SCDs
  • Average effect across cases, so conceals within-study variation
Summary

• Meta-analysis of case-level effect size estimates
  • Useful when synthesizing collections of SCDs that use varied outcomes.

• Meta-analysis of raw data
  • Useful when synthesizing collections of SCDs that use common outcome measures.

• Meta-analysis of study-level effect size estimates
  • Useful when synthesizing both SCDs and between-subjects studies.
Areas for meta-analysts to contribute

• Methods development
  • multi-variate effect sizes (case-level and study-level)
  • model selection

• Help single-case researchers develop strong protocols
  • Search strategies including grey literature
  • Careful attention to types of outcome measurements
  • Develop pre-specified analytic plans

• Worry about & investigate publication bias.

• Emphasize organized data, organized workflows, open science practices.
References


References


Estimating between-case SMDs:

The broad strategy (Pustejovsky, Hedges, & Shadish, 2014):

1. Develop a hierarchical model that describes
   a) the functional relationship for each case and
   b) how the outcome and functional relationship vary across cases.

2. Use the hierarchical model to imagine a hypothetical between-subjects experiment with the same population of participants, same treatment, same outcomes.

3. Calculate the between-case SMD for the hypothetical experiment.
**Publication/reporting bias**

- **Publication bias**: Certain types of results are more likely to be published, so that the published literature is not representative of the full “population” of findings.

- **Reporting bias**: Certain types of results are more likely to be reported (i.e., included in a research write-up), so that results included in published (or even unpublished) write-ups are not representative of the full “population” of findings.
Publication/reporting bias in single-case research

• Good reason to expect that publication biases affect single-case research
  • Strong emphasis on experimental control, visually detectable functional relationships (Tincanci & Travers, 2017)

• Emerging evidence that publication bias exists in single-case literature too
  • Sham & Smith (2014) found that findings from published studies were larger than those from unpublished dissertations in a synthesis of SCDs on pivotal response training.
  • Single-case researchers report that they are more likely to submit/accept for publication studies with larger effects (Shadish et al., 2016).

• But statistical significance filtering does not seem plausible as a mechanism