

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

James E. Pustejovsky

pusto@austin.utexas.edu

April 15, 2018

AERA NYC

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



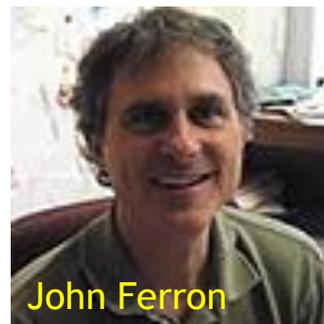
Tasha Beretvas



David Rindskopf



Patrick Onghena



John Ferron



Swami



Rob Horner



Larry Hedges



Mariota Moeyaert



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

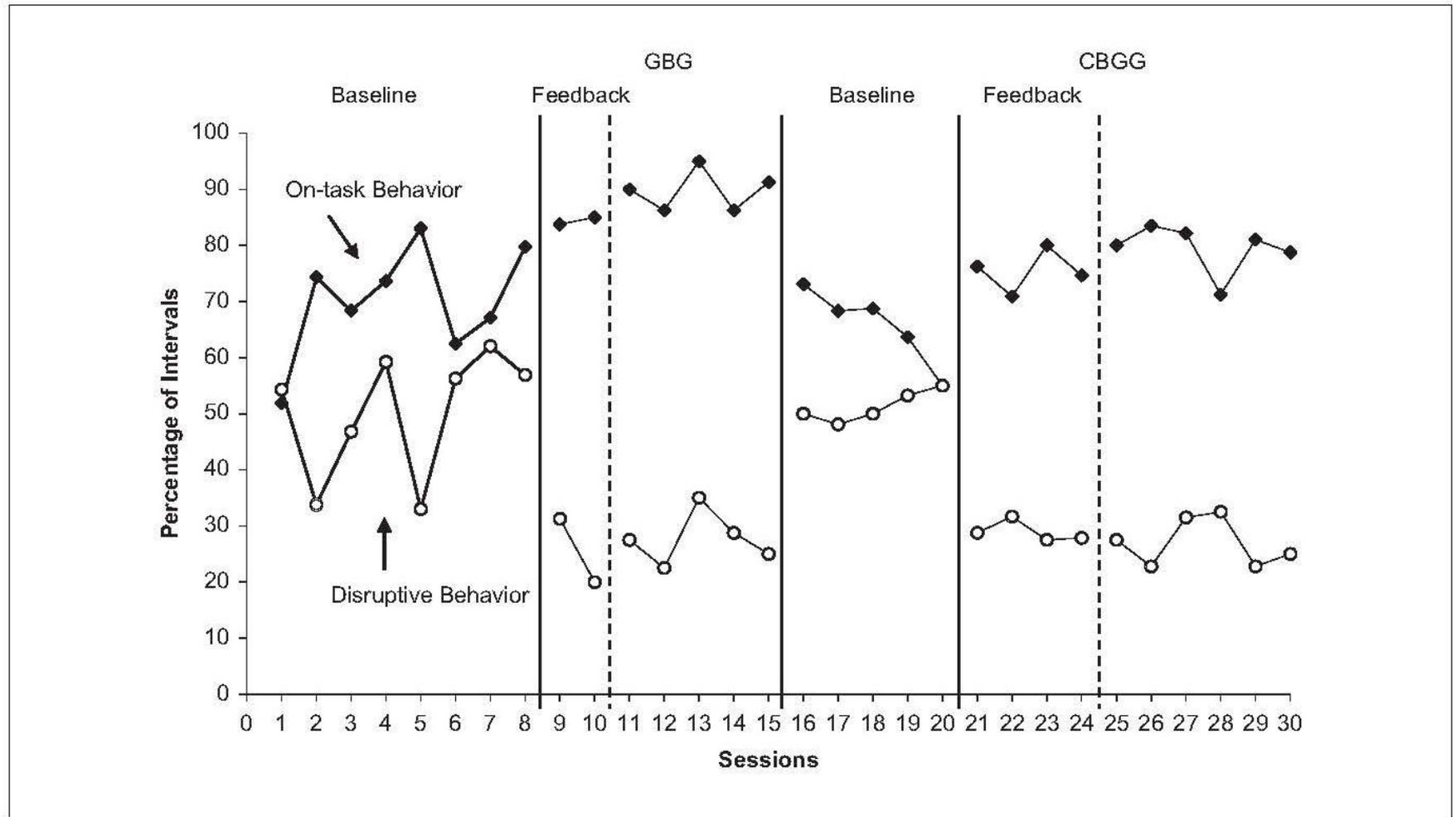
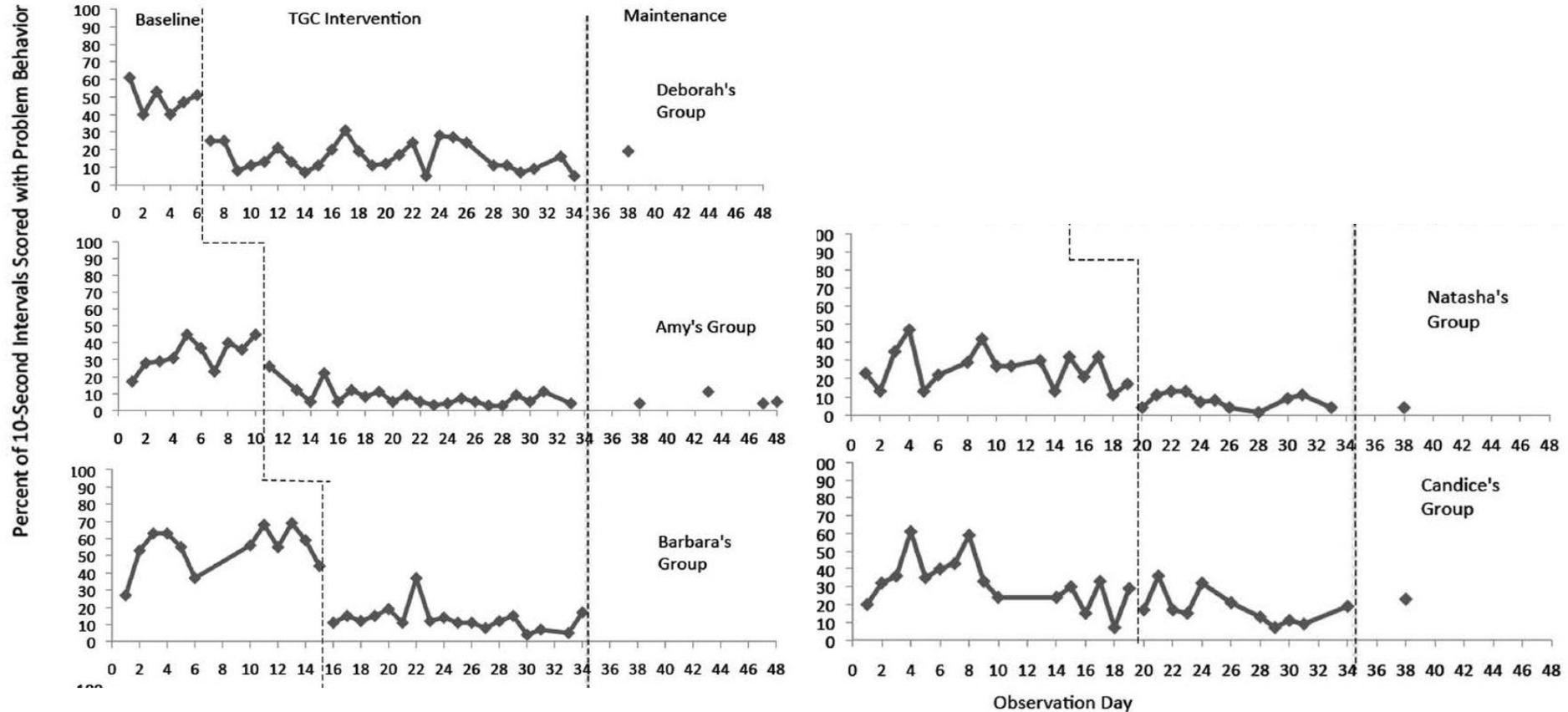


Figure I. Percentage of intervals showing disruptive and on-task behaviors in a kindergarten classroom.

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):

$$Y_{hij} = \beta_{0ij} + Trt_{ijt}\beta_{1ij} + e_{hij}$$

$$\beta_{0ij} = \gamma_0 + u_{0j} + v_{0ij}$$

$$\beta_{1ij} = \gamma_1 + u_{1j} + v_{1ij}$$

- 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

- Methods developed in Hedges, Pustejovsky, & Shadish (2012, 2013), Pustejovsky, Hedges, & Shadish (2014).
 - 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

- Busk, P. L., & Serlin, R. C. (1992). Meta-analysis for single-case research. In T. R. Kratochwill & J. R. Levin (Eds.), *Single-Case Research Design and Analysis: New Directions for Psychology and Education* (pp. 187-212). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.
- Hedges, L. V, Pustejovsky, J. E., & Shadish, W. R. (2012). A standardized mean difference effect size for single case designs. *Research Synthesis Methods*, 3, 224-239. doi:10.1002/jrsm.1052
- Hedges, L. V, Pustejovsky, J. E., & Shadish, W. R. (2013). A standardized mean difference effect size for multiple baseline designs across individuals. *Research Synthesis Methods*, 4(4), 324-341. doi:10.1002/jrsm.1086
- Ma, H. H. (2006). An alternative method for quantitative synthesis of single-subject researches: Percentage of data points exceeding the median. *Behavior Modification*, 30(5), 598.
- Moeyaert, M., Ugille, M., Ferron, J. M., Beretvas, S. N., & Van den Noortgate, W. (2013). The three-level synthesis of standardized single-subject experimental data: A monte carlo simulation study. *Multivariate Behavioral Research*, 48(5), 719-748. <http://doi.org/10.1080/00273171.2013.816621>
- Moeyaert, M., Ugille, M., Ferron, J. M., Beretvas, S. N., & Van den Noortgate, W. (2014). Three-level analysis of single-case experimental data: Empirical validation. *The Journal of Experimental Education*, 82(1), 1-21. <http://doi.org/10.1080/00220973.2012.745470>
- Parker, R. I., & Vannest, K. J. (2009). An improved effect size for single-case research: Nonoverlap of all pairs. *Behavior Therapy*, 40(4), 357-67.
- Pustejovsky, J. E., Hedges, L. V, & Shadish, W. R. (2014). Design-comparable effect sizes in multiple baseline designs: A general modeling framework. *Journal of Educational and Behavioral Statistics*, 39(5), 368-393.
- Pustejovsky, J. E. (2015). Measurement-comparable effect sizes for single-case studies of free operant behavior. *Psychological Methods*. doi:10.1037/met0000019
- Pustejovsky, J. E., & Ferron, J. M. (2017). Research synthesis and meta-analysis of single-case designs. In J. M. Kaufmann, D. P. Hallahan, & P. C. Pullen (Eds.), *Handbook of Special Education, 2nd Edition*. New York, NY: Routledge.
- Pustejovsky, J. E. (2018a). Procedural sensitivities of effect sizes for single-case designs with behavioral outcome. *Psychological Methods*, forthcoming. Retrieved from <https://osf.io/p3nuz/>
- Pustejovsky, J. E. (2018b). Using response ratios for meta-analyzing single-case designs with behavioral outcomes. *Journal of School Psychology*, 68. <http://doi.org/10.1016/j.jsp.2018.02.003>
- Rodriguez, B. J., & Anderson, C. M. (2014). Integrating a social behavior intervention during small group academic instruction using a total group criterion intervention. *Journal of Positive Behavior Interventions*, 16(4), 234-245. doi:10.1177/1098300713492858
- Scruggs, T. E., Mastropieri, M. A., & Casto, G. (1987). The quantitative synthesis of single-subject research: Methodology and validation. *Remedial and Special Education*, 8(2), 24-43. doi:10.1177/074193258700800206

References

- Shadish, W. R., Hedges, L. V, Horner, R. H., & Odom, S. L. (2015). The role of between-case effect size in conducting, interpreting, and summarizing single-case research. Washington, DC. Retrieved from <http://ies.ed.gov/ncser/pubs/2015002/>
- Shadish, W. R., Rindskopf, D. M., & Hedges, L. V. (2008). The state of the science in the meta-analysis of single-case experimental designs. *Evidence-Based Communication Assessment and Intervention*, 2(3), 188-196. doi:10.1080/17489530802581603
- Van den Noortgate, W., & Onghena, P. (2008). A multilevel meta-analysis of single-subject experimental design studies. *Evidence-Based Communication Assessment and Intervention*, 2(3), 142-151. <http://doi.org/10.1080/17489530802505362>
- Ugille, M., Moeyaert, M., Beretvas, S. N., Ferron, J. M., & Van den Noortgate, W. (2012). Multilevel meta-analysis of single-subject experimental designs: A simulation study. *Behavior Research Methods*. <http://doi.org/10.3758/s13428-012-0213-1>
- Wright, R. A., & McCurdy, B. L. (2012). Class-wide positive behavior support and group contingencies: Examining a positive variation of the Good Behavior Game. *Journal of Positive Behavior Interventions*, 14(3), 173-180. <http://doi.org/10.1177/1098300711421008>

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