5-4-21: Note - Poster is out of date; this work is under revision

Academy of Aphasia 2020

A Systematic Appraisal of Individual Effect Size Estimates in Aphasia Single-Case Designs via Simulation

[1,2]Robert Cavanaugh, [3]Lauren Terhorst, [1,2]Alexander M. Swiderski, [2]William D. Hula, [1,2]William S. Evans

[1] Communication Sciences & Disorders, University of Pittsburgh
[2] VA Pittsburgh Healthcare System
[3] Occupational Therapy, University of Pittsburgh

Introduction

Single-case designs are common in aphasia research (SCD; small-N; single-subject)

Effect sizes are central to evaluating treatment response in SCDs

Testing behavioral & neuro predictors requires accurate and precise effect sizes

A Range of effect sizes have been employed in aphasia single-case design studies

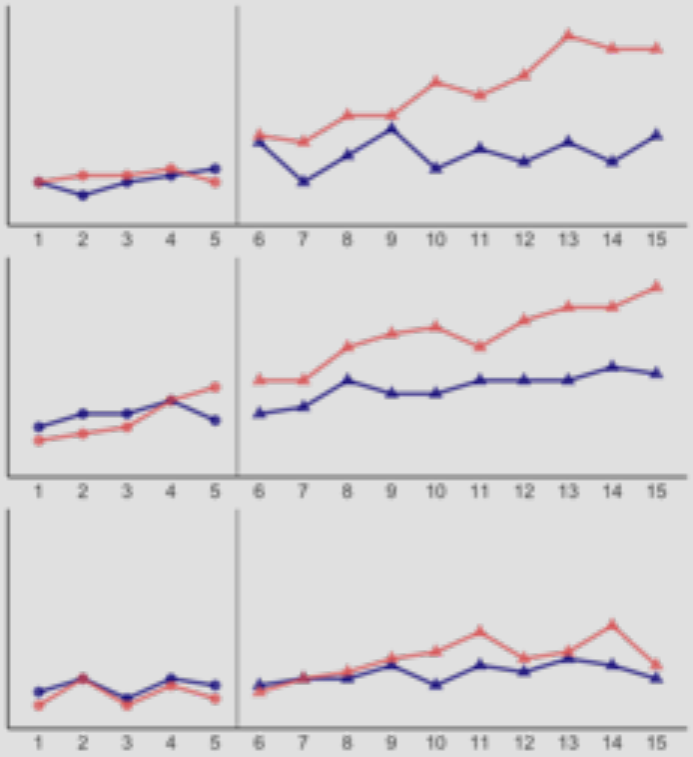
Not all are equivalent nor equally rigorous

Few empirical comparisons & limited guidance for aphasia researchers

Purpose: systematically compare effect sizes used in contemporary aphasia single case design research

Methods

1. Simulate (Manolov & Solonas, 2008)
    - N = 100, Multiple-baseline (AB) design
    - 5 baseline and 10 treatment probes
    - 30 treated & 30 untreated words



- intercept: $N(\mu = -1.75, \sigma^2 = .25)$
- participant: $unif(0, 2)$
- item: $N(\mu = 0, \sigma^2 = 0.6)$
- condition: treated = 1; untreated = 0
- logistic link function probability of correct response
- probabilitistic simulation: autocorrelated data (rho = 0.5)

$$response = intercept + 0.06 * baselineSlope + 0.3 * levelChange * particpant * condition + 0.15 * slopeChange * particpant * condition + itemDifficulty$$

Visual Inspection; Recover parameters Beeson & Robey quantiles: 3.2 (4.0), 6.8 (7.0), 10.6 (10.1)

Methods

2. Calculate Effect Sizes:*

- Standardized mean difference (**SMD**; Busk & Serlin 1992, Beeson & Robey, 2006)
- Non-overlap of all pairs (**NAP**; Parker & Vannest, 2009)
- **Tau-U** (Parker et al., 2011; Lee & Cherney, 2018)
- Proportion of potential maximal gain (**PMG**; Lambon Ralph et al., 2010)
- Generalized linear mixed-effects models (**GLMM**; Wiley & Rapp, 2018; Meier et al., 2019)
- Bayesian mixed-effects models (**BMEM** Hutiema & McKean, 2000; Evans et al., 2020)

3. Compare agreement between effect sizes:

- Standardized (z-scored) effect sizes within method & condition
- Agreement estimated using concordance correlation coefficients (Lin, 1989)
  - Estimated via non-parametric U-statistics & bootstrapped 95% CIs (King, 2001)

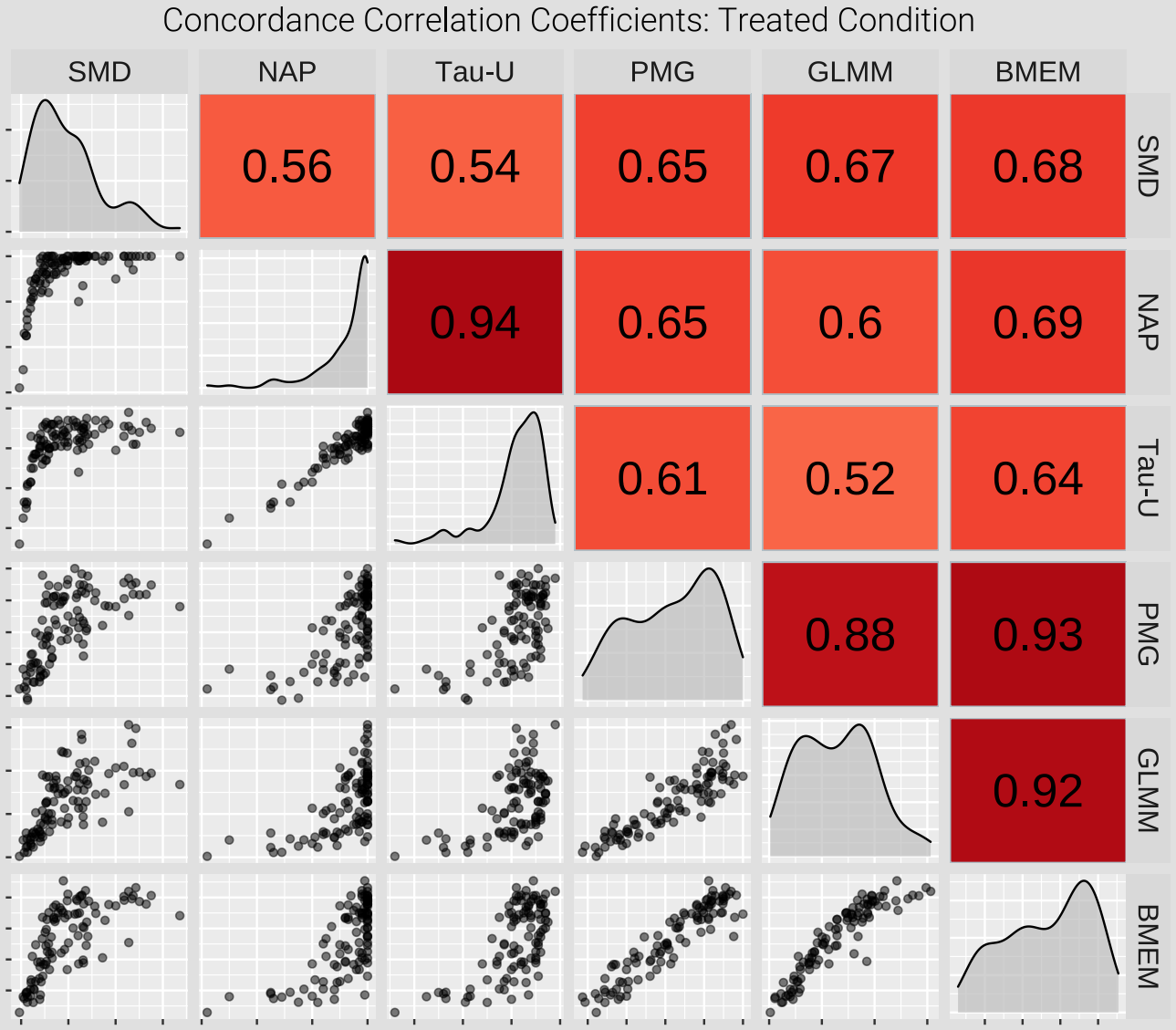
[*] for a primer on each measure, see link at end of slides

Results

Summary - Treated

1. Excellent agreement: mixed effect measures & PMG
2. Excellent agreement: Tau-U & NAP
3. Ceiling effects: NAP; Tau-U
4. SMD: disagreement increasing with effect size magnitude

Coefficients: < 0.40 = poor; 0.40 - 0.75 = fair to good; > 0.75 = good to excellent;

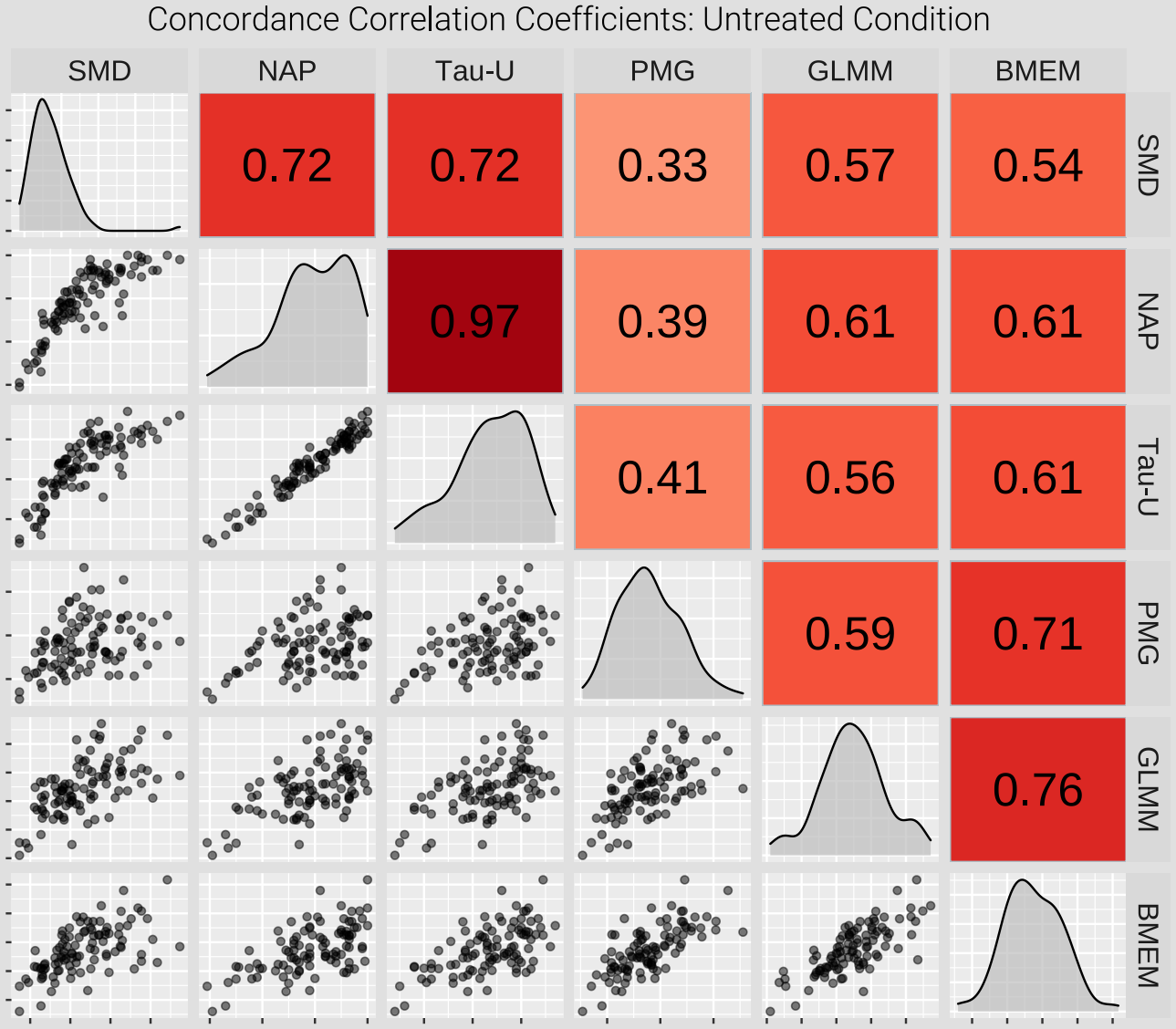


Results

Summary - Untreated

1. Excellent agreement: Tau-U & NAP
2. No ceiling effects
3. Poor agreement between PMG & SMD/NAP/Tau-U
4. SMD: heterscedasticity remains

Coefficients: < 0.40 = poor; 0.40 - 0.75 = fair to good; > 0.75 = good to excellent;



Findings

1. Careful (a priori) selection & use of effect size measures matters
    - measures are far from interchangeable
    - Effect size selection likely to affect study findings
2. Ceiling effects and rising baselines remain core unresolved issues
    - should be addressed with careful experimental design.
3. Continue to evaluate new methods:
    - Revised Baseline-corrected Tau (Tarlow, 2017: https://doi.org/10.1177/0145445516676750)
    - Log Response Ratio or Log Odds Ratio (Pustejovsky, 2015: https://doi.org/10.1037/met0000019)

Selection = dependent variable + experimental design + expected treatment pattern

Specific Recommendations

1. Given criticisms + available alternatives, recommend against future use of SMD.
    - no meaningful changes substituting Beeson & Robey's *d* for SMD
2. GLMMs and their Bayesian extensions satisfy most criteria for effect sizes:
    - accounting for baseline trends (within reason) & minimizing ceiling effects
    - providing relatively clear estimates of effect *magnitude and uncertainty.*
3. PMG approximates mixed effects approaches but lacks certainty/significance.
    - need to combine with an approach such as weighted statistics
4. NAP & Tau-U provide similar results when treatments effects are gradual and/or small but lose sensitivity when effect sizes are medium to large.

Selected References

Beeson, P. M., & Robey, R. R. (2006). Evaluating single-subject treatment research: Lessons learned from the aphasia literature. Neuropsychology Review, 16(4), 161–169. https://doi.org/10.1007/s11065-006-9013-7

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 (p. 187–212). Lawrence Erlbaum Associates, Inc.

Evans, W. S., Cavanaugh, R. B., Quique, Y. L., Boss, E., Starns, J. J., Hula, W. D. (manuscript under review). Playing with BEARS: Balancing Effort, Accuracy, and Response Speed in a Semantic Feature Verification Anomia Treatment Game.

Goldfeld, K. (2019). simstudy: Simulation of Study Data (R package). https://cran.r-project.org/package=simstudy

Huitema, B. E., & Mckean, J. W. (2000). Design specification issues in time-series intervention models. Educational and Psychological Measurement, 60(1), 38–58.https://doi.org/10.1177/00131640021970358

King, T. S., & Chinchilli, V. M. (2001). A generalized concordance correlation coefficient for continuous and categorical data. Statistics in Medicine, 20(14), 2131–2147. https://doi.org/10.1002/sim.845

Lin, L. I.-K. (1989). A Concordance Correlation Coefficient to Evaluate Reproducibility. Biometrics, 45(1), 255–268. JSTOR. https://doi.org/10.2307/2532051

Lambon Ralph, M. A., Snell, C., Fillingham, J. K., Conroy, P., & Sage, K. (2010). Predicting the outcome of anomia therapy for people with aphasia post CVA: both language and cognitive status are key predictors. Neuropsychological Rehabilitation, 20(2), 289–305. https://doi.org/10.1080/09602010903237875

Manolov, R., & Solanas, A. (2008). Comparing N = 1 Effect Size Indices in Presence of Autocorrelation. Behavior Modification, 32(6), 860–875. https://doi.org/10.1177/0145445508318866

Parker, R. I., & Vannest, K. (2009). An improved effect size for single-case research: Nonoverlap of all pairs. Behavior Therapy, 40(4), 357–367. https://doi.org/10.1016/j.beth.2008.10.006

Parker, R. I., Vannest, K. J., Davis, J. L., & Sauber, S. B. (2011). Combining nonoverlap and trend for single-case research: Tau-U. Behavior Therapy, 42(2), 284–299. https://doi.org/10.1016/j.beth.2010.08.006

Wiley, R. W., & Rapp, B. (2018). Statistical analysis in Small-N Designs: Using linear mixed-effects modeling for evaluating intervention effectiveness. Aphasiology, 33(1), 1–30. https://doi.org/10.1080/02687038.2018.1454884

Thank You -

More Resources:

- Effect Size Primer: rb-cavanaugh.shinyapps.io/aphasia-effect-sizes/
- R code & data: https://osf.io/6x5pd/

Acknowledgements

- Natalie Gilmore & Robery Wiley
- Pitt ICRE TL1 Predoctoral Fellowship Program (1TL1TR001858, PI: Kraemer)

Contact: rob.cavanaugh@pitt.edu