A Simple Effect Size Indicator for the Meta-Analysis of Single Participant Design Studies

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Introduction

- Meta-analyses and research syntheses of studies conducted as part of several OSEP-funded Research and Training Centers and Early Childhood Technical Assistance Centers have included effect sizes as metrics for estimating the influence of different types of interventions on child and adult outcomes

- Calculating effect sizes for single participant design studies has proven challenging because effect size formulas often yield extreme outliners (e.g., Cohen's *d*)

Purposes of the Presentation

- Describe the use of the point-biserial correlation coefficient as an effect size estimate for meta-analyses of single participant design studies
- Illustrate it applicability for individual cases and for combining effect size estimates from individual cases

Meta-Analyses of Single Participant Design Studies

- Methods for calculating "sizes of effect" from findings reported in single participant design studies range from simple percent of non-overlap indices to multilevel modeling indices

- Non-overlap indices have been criticized because of undesirable statistical properties (Wolery et al., 2010)

- Multilevel modeling indices seem unnecessarily uncomplex (at least for the kinds of studies my colleagues and I have been examining)

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Wolery, M., Busick, M., Reichow, B., & Baron, E. E. (2010). Comparison of overlap methods for quantitatively synthesizing single subject data. *Journal of Special Education*, 44, 18-28.

Point-Biserial Correlation Coefficient
As an Effect Size Estimate

R.W. Marsh (1982) proposed the use of the point-biserial correlation coefficient as an effect size for evaluating the impact of interventions in single participant design studies 30 years ago

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Marsh, R.W. (1982). The use of serial correlation in the analysis of data from interrupted time series trials with single subjects in educational research. *Educational Psychology*, 4, 317-320.

Adoption of Marsh's Proposed Effect Size

A *Social Science Citation Index* search for researchers citing or using the Marsh (1982) effect size estimate found only three citations between 1982 and 2006, and only two citations in the past five years (Dunst & Hamby, 2012; Eells, 2007)

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     Dunst, C.J., & Hamby, D.W. (2012). Guide for calculating and interpreting effect sizes and confidence intervals in intellectual and developmental disabilities research studies. *Journal of Intellectual and Developmental Disability,* 37, 89-99.

     Eells, T.D. (2007). Generating and generalizing knowledge about psychotherapy from pragmatic case studies. *Pragmatic Case Studies in Psychotherapy*, 3, 35-54.

Why the Point-Biserial Coordination As an Effect Size?

- A hallmark of single participant design studies is the individual as the unit of analysis where "performance prior to intervention is compared to performance during and/or after intervention" (Horner et al., 2005, p. 166)
- The point-biserial correlation coefficient appears to be a useful metric for estimating the size of effect for quantifying before-after contrasts (Rosnow et al., 2000)

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Horner, R. H., Halle, J., McGee, G., Odom, S., & Wolery, M. (2005). The use of single-subject research to identify evidence-based practice in special education. *Exceptional Children*, 71, 165-179.

Rosnow, R. L., Rosenthal, R., & Rubin, D. B. (2000). Contrasts and correlations in effect-size estimation. *Psychological Science*, 11, 446-453.

Coding Single Participant Design Study Data
for Computing a Point-Biserial Correlation
(Hypothetical Data for Illustrative Purposes)

Session	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Baseline	2	4	3	1	0	2	3	2												
Intervention									4	6	5	8	12	10	12	11	9	14	14	13
Condition	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1

Point-Biserial r = 0.82

Use of the Point-Biserial Correlation Coefficient as an Effect Size

- So far, I have been able to locate on two studies (Gray & Milne, 1986; Kraemer, 1978) where individual participant data were analyzed using the point-biserial correlation coefficient to relate between condition differences to variations in outcome measures of interest

- Kraemer (1978) performed what is the equivalent of a meta-analysis by noting that the correlations for 16 of her 19 participants were positive where the average correlation for all participants combined was 0.56.

Gray, D., & Milne, D. (1986). Effect of dietary supplements on acute mountain sickness. *Perceptual and Motor Skills*, 63, 873-874.

Kraemer, H. C. (1978). Individual and ecological correlation in a general context. *Behavioral Science*, 23, 67-72.

Examples of Using the Point-Biserial Correlation Coefficient as an Effect Size

# Early Contingency Learning and Child Concomitant Social-Emotional Behavior

- Contingency learning games for promoting children's acquisition of instrumental behavior
- Multiple-baseline design across study participants
- Measured increases in the children's use of instrumental behavior used to produce interesting consequences or reinforcing events

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  Raab, M., Dunst, C.J. Wilson, L.L., & Parkey C. (2009). Early contingency learning and child and teacher concomitant social-emotional behavior. *International Journal of Early Childhood Special Education*, 1(1), 1 – 14.

Characteristics of the Study Participants

Child	Chronological Age (Months)	Developmental Age (Months)	Development Quotient	Diagnosis [a]		
				CP	VI	Seizures
"Amy"	34	5	16	✓	✓	
"Brenda"	48	4	9	✓	✓	
"Cory"	52	3	6	✓		✓

[a] CP = Cerebral palsy, VI = Visual impairment.
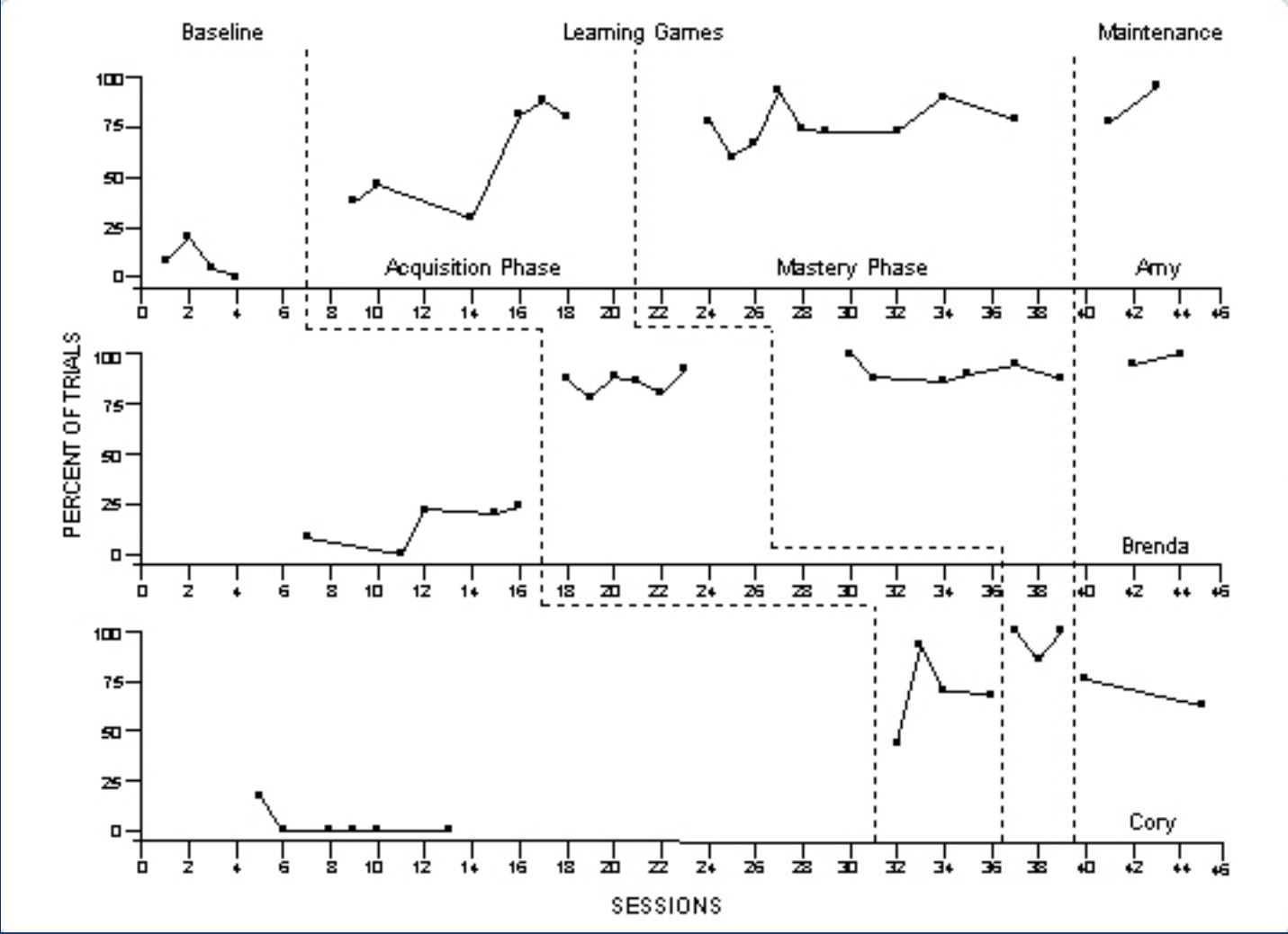
Effect Size Estimates of the Learning Games

| Child	Cohen's d	Point-Biserial Correlation	Fisher's z
Amy	3.97	0.82	1.16
Brenda	8.25	0.98	2.30
Cory	5.17	0.94	1.74
Average Effect Size	5.80	0.91	1.73

Effects of Interest-Based Interventions on the Social-Communicative Behavior of Young Children with Autism Spectrum Disorders

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CELLreview, 2012, 5(5)

Selected Characteristics of the Studies

- 14 single participant design studies including 30 children
- Median sample size was 3 (range 1 to 4)
- Mean child age was 52 months (Range = 26-72)
- Mean child mental age was 32 months (Range = 14 – 61)
- Child interest measures categorized as either personal or situational interests
- Child outcome measures categorized as positive affect and socially responsive (prosocial behavior) or joint attention and language (communicative behavior)
- Point-biserial correlation used as estimate of the effect size of the interventions and the 95% confidence interval was used as the measure of the reliability of the estimate

Average Effect Sizes and 95% Confidence Intervals for the Relationship Between the Interest-Based Interventions and the Child Outcomes
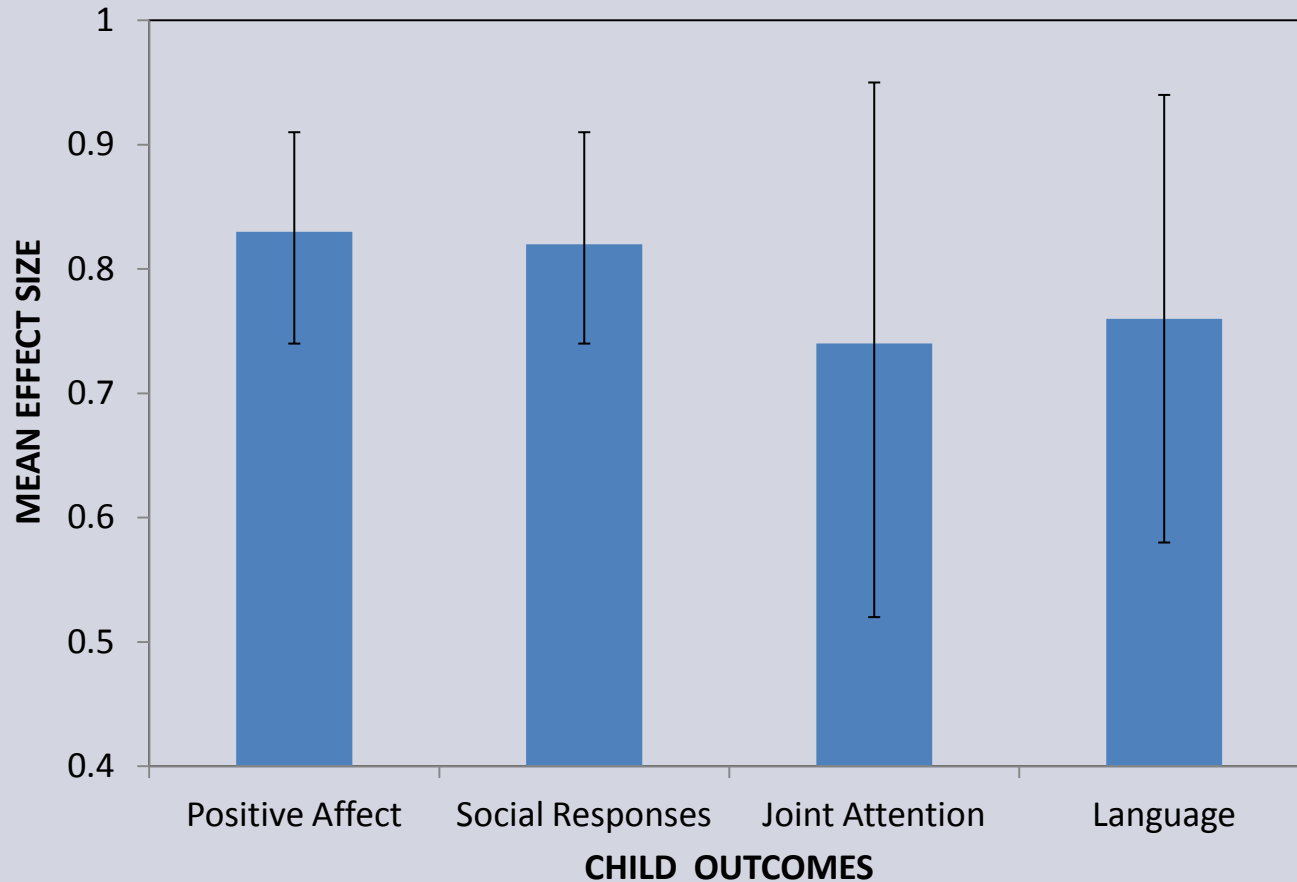
Average Effect Sizes and 95% Confidence Intervals for the Influence of Personal and Situational Interests on the Child Outcomes
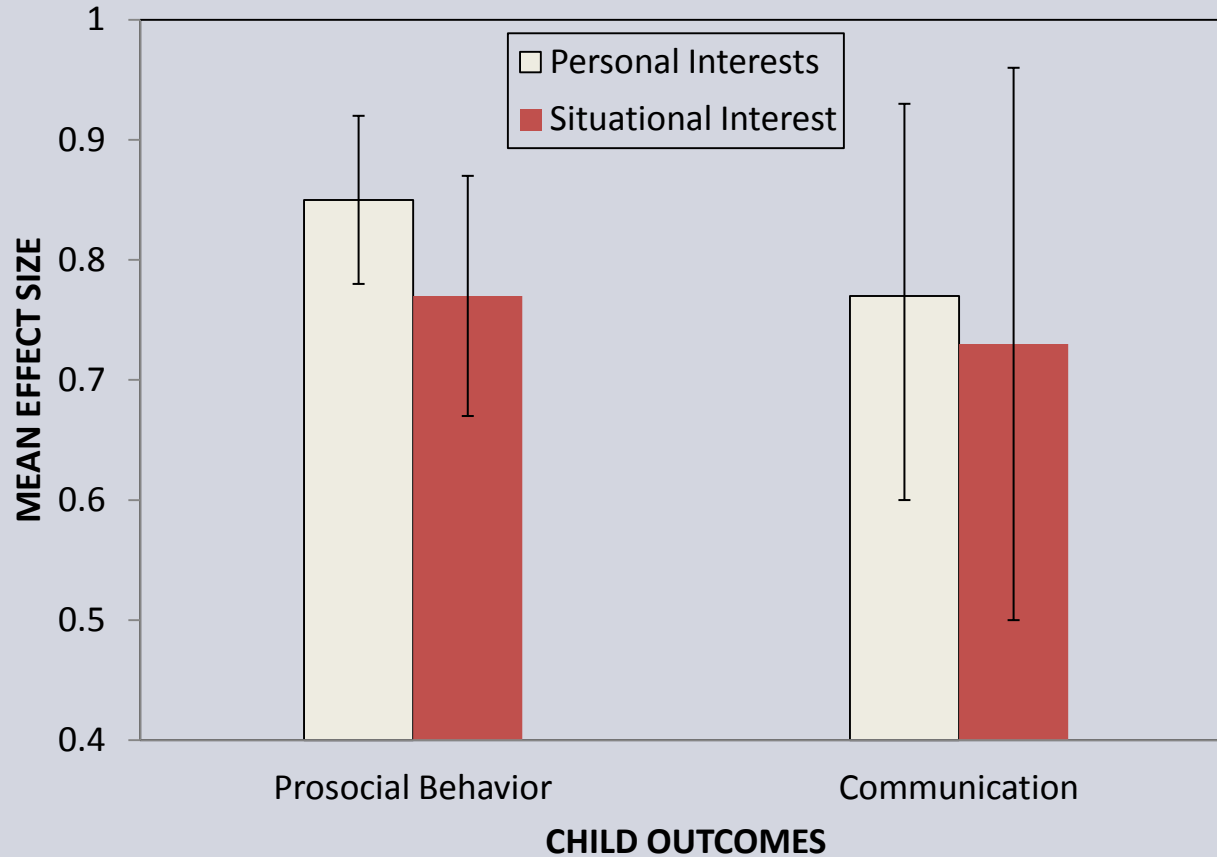
Average Effect Sizes and 95% Confidence Intervals for the Influence of Child Characteristics and Intervention Setting on the Study Outcomes

Moderators	Number of Effect Sizes	Average Effect Size	95% Confidence Intervals
Child Gender			
Male	42	.81	.75-.87
Female	13	.78	.63-.92
Child Severity			
Mild	26	.82	.74-.90
Moderate/Severe	29	.78	.71-.86
Intervention Setting			
Home/Community	11	.88	.78-.97
Classroom	19	.80	.69-.91
Clinic	25	.77	.69-.85

Fisher *z* Transformation
of the Point-Biserial Correlation

Because of the statistical properties of the sampling distribution of correlation coefficients, it is generally recommended that r's be converted to Fisher *z*'s before calculating average effect sizes and confidence intervals, and then convert the *z*'s back to r's for reporting and interpretation purposes

Why Transform the Point-Biserial Correlation to Fisher's *z*?

- Distribution of larger *r*'s is almost always negatively skewed

- Differences between large *r*'s are greater than differences between smaller *r*'s

- Distribution of *z*'s are symmetrical around an average (i.e., normal sampling distribution)

- The confidence interval for an average *z* is a more accurate estimate of the true range of effect sizes

Problems with Transformed Correlation Coefficients

According to Hunter and Schmidt (2004), the Fisher z transformation produces "an upward bias when it is used in averaging correlations" (p. 82) where the bias is more pronounced when the correlation coefficients that are being transformed and averaged are large. They recommend that "all calculations be performed directly on the correlation coefficients" (p. 203).

Hunter, J.E., & Schmidt, F.L. (2004). *Methods of meta-analysis: Correcting error and bias in research findings,* Thousand Oaks, CA: Sage.

Transforming Effect Sizes in the Meta-Analysis of Single Participant Design Studies

- Our experiences thus far have shown that the largest number of effect sizes in single participant design studies are typically 0.70 or larger and the distributions are negatively skewed

- More than half a dozen methods for correcting upwardly biased effect sizes have been used to adjust the effect sizes in our single participant design meta-analyses but none have proven useful

- At this point in the search for an appropriate effect size for synthesizing findings from single participant design studies, our recommendation is not to use transformation Fisher *z*

Effects of the Transformation
of the Point-Biserial Correlations

The effects transforming or not transforming the point-biserial correlation coefficient to Fisher's z is illustrated with the Autism interest-based synthesis data to show how the two procedures yield different results

Nontransformed and Transformed Effect Sizes and 95% CIs
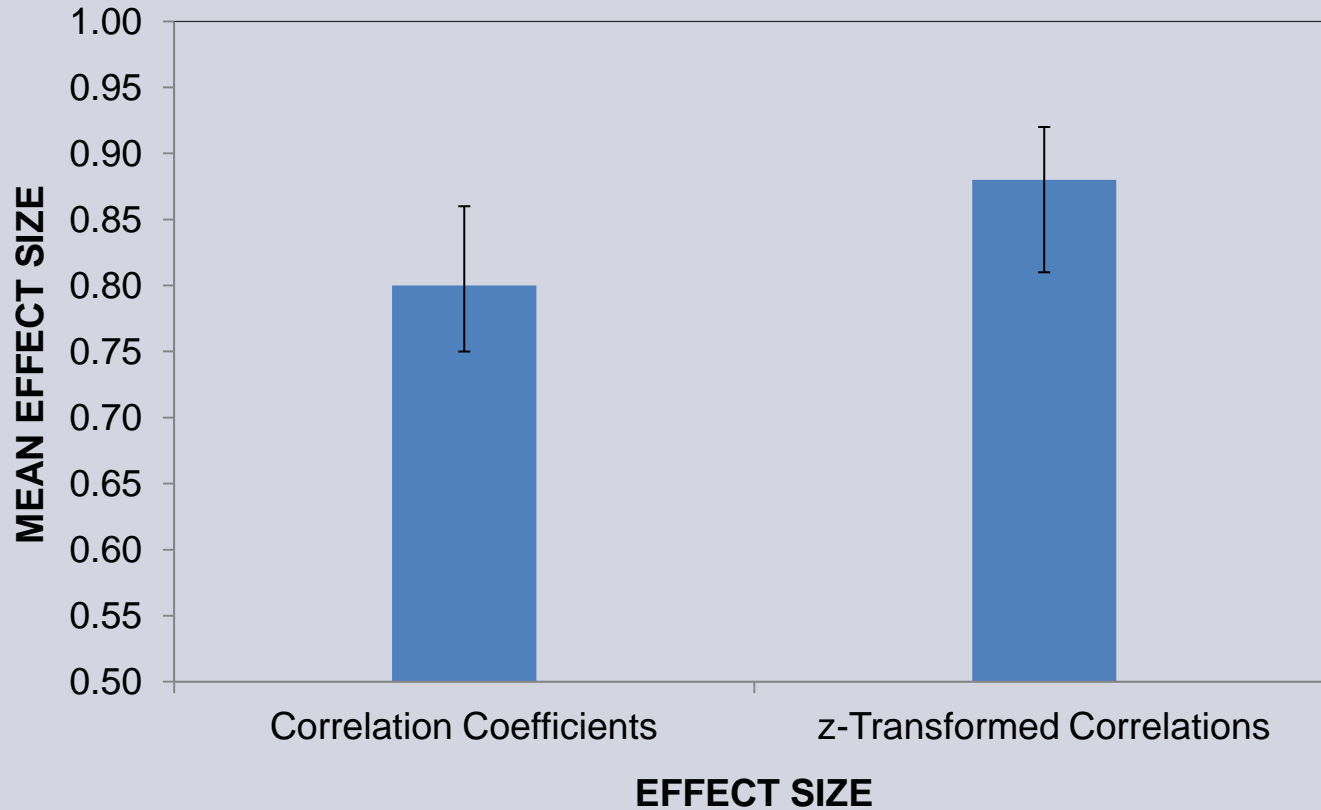
Conclusions

- The point-biserial correlation coefficient is a simple, straightforward method for calculating effect sizes from single participant design studies

- Different methods for transforming the point-biserial correlation coefficient appear to upwardly bias effect size estimates and therefore are not recommended

- Further research and analysis is however needed to be sure the point-biserial correlation coefficient for single participant design studies behaves in the same way as when used in group design studies

- The point-biserial correlation coefficient nonetheless appears to be a reasonable alternative to other effect size estimates for single participant design studies

PowerPoint presentation available at
www.puckett.org