Package ‘PowerUpR’

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Title Power Analysis Tools for Multilevel Randomized Experiments
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Description Includes tools to calculate statistical power, minimum detectable effect size (MDES), MDES difference (MDESD), and minimum required sample size for various multilevel randomized experiments with continuous outcomes. Some of the functions can assist with planning two- and three-level cluster-randomized trials (CRTs) sensitive to multilevel moderation and mediation (2-1-1, 2-2-1, and 3-2-1). See ‘PowerUp!’ Excel series at <https://www.causalevaluation.org/>.

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### Description

*PowerUp!* series consist of three excel-based applications to design various multilevel randomized experiments to detect main treatment effects, and to design two- and three-level cluster-randomized trials (CRTs) to detect multilevel moderation and mediation. For more information please refer to [http://www.causalevaluation.org/](http://www.causalevaluation.org/).

### bcra3f2

**Three-Level Blocked (Fixed) Cluster-level Random Assignment Design, Treatment at Level 2**

#### Description

Use `mdes.bcra3f2()` to calculate the minimum detectable effect size, `power.bcra3f2()` to calculate the statistical power, and `mrss.bcra3f2()` to calculate the minimum required sample size.

#### Usage

```r
mdes.bcra3f2(power=.80, alpha=.05, two.tailed=TRUE,
              rho2, p=.50, g2=0, r21=0, r22=0,
              n, J, K)

power.bcra3f2(es=.25, alpha=.05, two.tailed=TRUE,
               rho2, p=.50, g2=0, r21=0, r22=0,
               n, J, K)

mrss.bcra3f2(es=.25, power=.80, alpha=.05, two.tailed=TRUE,
             n, J, K0=10, tol=.10,
             rho2, p=.50, g2=0, r21=0, r22=0)
```
Arguments

- **power**: statistical power \((1 - \beta)\).
- **es**: effect size.
- **alpha**: probability of type I error.
- **two.tailed**: logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
- **rho2**: proportion of variance in the outcome between level 2 units (unconditional ICC2).
- **p**: average proportion of level 2 units randomly assigned to treatment within level 3 units.
- **g2**: number of covariates at level 2.
- **r21**: proportion of level 1 variance in the outcome explained by level 1 covariates.
- **r22**: proportion of level 2 variance in the outcome explained by level 2 covariates.
- **n**: harmonic mean of level 1 units across level 2 units (or simple average).
- **J**: harmonic mean of level 2 units across level 3 units (or simple average).
- **K**: number of level 3 units.
- **K0**: starting value for \(K\).
- **tol**: tolerance to end iterative process for finding \(K\).

Value

- **fun**: function name.
- **parms**: list of parameters used in power calculation.
- **df**: degrees of freedom.
- **ncp**: noncentrality parameter.
- **power**: statistical power \((1 - \beta)\).
- **mdes**: minimum detectable effect size.
- **K**: number of level 3 units.

Examples

```
# cross-checks
mdes.bcra3f2(rho2=.10, n=20, J=44, K=5)
power.bcra3f2(es = .145, rho2=.10, n=20, J=44, K=5)
mrss.bcra3f2(es = .145, rho2=.10, n=20, J=44)
```
Description

Use `mdes.bcra3r2()` to calculate the minimum detectable effect size, `power.bcra3r2()` to calculate the statistical power, and `mrss.bcra3r2()` to calculate the minimum required sample size.

Usage

```r
mdes.bcra3r2(power=.80, alpha=.05, two.tailed=TRUE,
               rho2, rho3, omega3, p=.50, g3=0, r21=0, r22=0, r2t3=0,
               n, J, K)
```

```r
power.bcra3r2(es=.25, alpha=.05, two.tailed=TRUE,
                rho2, rho3, omega3, p=.50, g3=0, r21=0, r22=0, r2t3=0,
                n, J, K)
```

```r
mrss.bcra3r2(es=.25, power=.80, alpha=.05, two.tailed=TRUE,
              n, J, K0=10, tol=.10,
              rho2, rho3, omega3, p=.50, g3=0, r21=0, r22=0, r2t3=0)
```

Arguments

- `power` statistical power \((1 - \beta)\).
- `es` effect size.
- `alpha` probability of type I error.
- `two.tailed` logical; `TRUE` for two-tailed hypothesis testing, `FALSE` for one-tailed hypothesis testing.
- `rho2` proportion of variance in the outcome between level 2 units (unconditional ICC2).
- `rho3` proportion of variance in the outcome between level 3 units (unconditional ICC3).
- `omega3` treatment effect heterogeneity as ratio of treatment effect variance among level 3 units to the residual variance at level 3.
- `p` average proportion of level 2 units randomly assigned to treatment within level 3 units.
- `g3` number of covariates at level 3.
- `r21` proportion of level 1 variance in the outcome explained by level 1 covariates.
- `r22` proportion of level 2 variance in the outcome explained by level 2 covariates.
- `r2t3` proportion of treatment effect variance among level 3 units explained by level 3 covariates.
- `n` harmonic mean of level 1 units across level 2 units (or simple average).
- `J` harmonic mean of level 2 units across level 3 units (or simple average).
**bcra4f3**

K  
number of level 3 units.

K0  
starting value for K.

tol  
tolerance to end iterative process for finding K.

**Value**

- **fun**: function name.
- **parms**: list of parameters used in power calculation.
- **df**: degrees of freedom.
- **ncp**: noncentrality parameter.
- **power**: statistical power \((1 - \beta)\).
- **mdes**: minimum detectable effect size.
- **K**: number of level 3 units.

**See Also**

cosa.bcrd3r2

**Examples**

```r
# cross-checks
mdes.bcra3r2(rho3=.13, rho2=.10, omega3=.4, n=10, J=6, K=24)
power.bcra3r2(es = .246, rho3=.13, rho2=.10, omega3=.4, n=10, J=6, K=24)
mrss.bcra3r2(es = .246, rho3=.13, rho2=.10, omega3=.4, n=10, J=6)
```

---

**bcra4f3**  
*Four-Level Blocked (Fixed) Cluster-level Random Assignment Design, Treatment at Level 3*

**Description**

Use `mdes.bcra4f3()` to calculate the minimum detectable effect size, `power.bcra4f3()` to calculate the statistical power, and `mrss.bcra4f3()` to calculate the minimum required sample size.

**Usage**

```r
mdes.bcra4f3(power=.80, alpha=.05, two.tailed=TRUE, rho2, rho3, p=.50, r21=0, r22=0, r23=0, g3=0, n, J, K, L)
power.bcra4f3(es=.25, alpha=.05, two.tailed=TRUE, rho2, rho3, p=.50, r21=0, r22=0, r23=0, g3=0, n, J, K, L)
```
mrss.bcra4f3(es=.25, power=.80, alpha=.05, two.tailed=TRUE,
  n, J, K, L0=10, tol=.10,
  rho2, rho3, p=.50, g3=0, r21=0, r22=0, r23=0)

Arguments

  power  statistical power \((1 - \beta)\).
  es      effect size.
  alpha   probability of type I error.
  two.tailed logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
  rho2    proportion of variance in the outcome between level 2 units (unconditional ICC2).
  rho3    proportion of variance in the outcome between level 3 units (unconditional ICC3).
  p       average proportion of level 3 units randomly assigned to treatment within level 4 units.
  g3      number of covariates at level 3.
  r21     proportion of level 1 variance in the outcome explained by level 1 covariates.
  r22     proportion of level 2 variance in the outcome explained by level 2 covariates.
  r23     proportion of level 3 variance in the outcome explained by level 3 covariates.
  n       harmonic mean of level 1 units across level 2 units (or simple average).
  J       harmonic mean of level 2 units across level 3 units (or simple average).
  K       harmonic mean of level 3 units across level 4 units (or simple average).
  L       number of level 4 units.
  L0      starting value for L.
  tol     tolerance to end iterative process for finding L.

Value

  fun      function name.
  parms    list of parameters used in power calculation.
  df       degrees of freedom.
  ncp      noncentrality parameter.
  power    statistical power \((1 - \beta)\).
  mdes     minimum detectable effect size.
  L        number of level 4 units.

Examples

  # cross-checks
  mdes.bcra4f3(rho3=.15, rho2=.15,
    n=10, J=4, K=4, L=15)
  power.bcra4f3(es=0.339, rho3=.15, rho2=.15,
    n=10, J=4, K=4, L=15)
  mrss.bcra4f3(es=0.339, rho3=.15, rho2=.15,
    n=10, J=4, K=4)
Four-Level Blocked Cluster-level Random Assignment Design, Treatment at Level 2

Description

Use `mdes.bcra4r2()` to calculate the minimum detectable effect size, `power.bcra4r2()` to calculate the statistical power, and `mrss.bcra4r2()` to calculate the minimum required sample size.

Usage

```r
mdes.bcra4r2(power=.80, alpha=.05, two.tailed=TRUE,
               rho2, rho3, rho4, omega3, omega4,
               p=.50, r21=0, r22=0, r2t3=0, r2t4=0, g4=0,
               n, J, K, L)
```

```r
power.bcra4r2(es=.25, alpha=.05, two.tailed=TRUE,
               rho2, rho3, rho4, omega3, omega4,
               p=.50, r21=0, r22=0, r2t3=0, r2t4=0, g4=0,
               n, J, K, L)
```

```r
mrss.bcra4r2(es=.25, power=.80, alpha=.05, two.tailed=TRUE,
              n, J, K, L, L0=10, tol=.10,
              rho2, rho3, rho4, omega3, omega4,
              p=.50, r21=0, r22=0, r2t3=0, r2t4=0, g4=0)
```

Arguments

- `power`: statistical power $(1 - \beta)$.
- `es`: effect size.
- `alpha`: probability of type I error.
- `two.tailed`: logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
- `rho2`: proportion of variance in the outcome between level 2 units (unconditional ICC2).
- `rho3`: proportion of variance in the outcome between level 3 units (unconditional ICC3).
- `rho4`: proportion of variance in the outcome between level 4 units (unconditional ICC4).
- `omega3`: treatment effect heterogeneity as ratio of treatment effect variance among level 3 units to the residual variance at level 3.
- `omega4`: treatment effect heterogeneity as ratio of treatment effect variance among level 4 units to the residual variance at level 4.
- `p`: average proportion of level 2 units randomly assigned to treatment within level 3 units.
- `g4`: number of covariates at level 4.
- `r21`: proportion of level 1 variance in the outcome explained by level 1 covariates.
proportion of level 2 variance in the outcome explained by level 2 covariates.

\( r_{22} \)

proportion of treatment effect variance among level 3 units explained by level 3 covariates.

\( r_{2t3} \)

proportion of treatment effect variance among level 4 units explained by level 4 covariates.

\( r_{2t4} \)

harmonic mean of level 1 units across level 2 units (or simple average).

\( n \)

harmonic mean of level 2 units across level 3 units (or simple average).

\( J \)

harmonic mean of level 3 units across level 4 units (or simple average).

\( K \)

number of level 4 units.

\( L \)

starting value for \( L \).

\( L_0 \)

tolerance to end iterative process for finding \( L \).

\( tol \)

Value

- **fun**: function name.
- **parms**: list of parameters used in power calculation.
- **df**: degrees of freedom.
- **ncp**: noncentrality parameter.
- **power**: statistical power \((1 - \beta)\).
- **mdes**: minimum detectable effect size.
- **L**: number of level 4 units.

See Also

cosa.bcrd4r2

Examples

```r
# cross-checks
mdes.bcra4r2(rho4=.05, rho3=.15, rho2=.15, omega4=.50, omega3=.50, n=10, J=4, K=4, L=20)
power.bcra4r2(es = .206, rho4=.05, rho3=.15, rho2=.15, omega4=.50, omega3=.50, n=10, J=4, K=4, L=20)
msrss.bcra4r2(es = .206, rho4=.05, rho3=.15, rho2=.15, omega4=.50, omega3=.50, n=10, J=4, K=4)
```
**Four-Level Blocked Cluster-level Random Assignment Design, Treatment at Level 3**

**Description**

Use `mdes.bcra4r3()` to calculate the minimum detectable effect size, `power.bcra4r3()` to calculate the statistical power, and `mrss.bcra4r3()` to calculate the minimum required sample size.

**Usage**

```r
mdes.bcra4r3(power=.80, alpha=.05, two.tailed=TRUE,
    rho2, rho3, rho4, omega4,
    p=.50, r21=0, r22=0, r23=0, r2t4=0, g4=0,
    n, J, K, L)
```

```r
power.bcra4r3(es=.25, alpha=.05, two.tailed=TRUE,
    rho2, rho3, rho4, omega4,
    p=.50, r21=0, r22=0, r23=0, r2t4=0, g4=0,
    n, J, K, L)
```

```r
mrss.bcra4r3(es=.25, power=.80, alpha=.05, two.tailed=TRUE,
    n, J, K, L0=10, tol=.10,
    rho2, rho3, rho4, omega4,
    p=.50, r21=0, r22=0, r23=0, r2t4=0, g4=0)
```

**Arguments**

- `power`: statistical power \((1 - \beta)\).
- `es`: effect size.
- `alpha`: probability of type I error.
- `two.tailed`: logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
- `rho2`: proportion of variance in the outcome between level 2 units (unconditional ICC2).
- `rho3`: proportion of variance in the outcome between level 3 units (unconditional ICC3).
- `rho4`: proportion of variance in the outcome between level 4 units (unconditional ICC4).
- `omega4`: treatment effect heterogeneity as ratio of treatment effect variance among level 4 units to the residual variance at level 4.
- `p`: average proportion of level 3 units randomly assigned to treatment within level 4 units.
- `g4`: number of covariates at level 4.
- `r21`: proportion of level 1 variance in the outcome explained by level 1 covariates.
- `r22`: proportion of level 2 variance in the outcome explained by level 2 covariates.
Two-Level Blocked (Constant Treatment Effect) Individual-level Random Assignment Design, Treatment at Level 1

Use `mdes.bira2c1()` to calculate the minimum detectable effect size, `power.bira2c1()` to calculate the statistical power, and `mrss.bira2c1()` to calculate the minimum required sample size.
Usage

```r
mdes.bira2c1(power=.80, alpha=.05, two.tailed=TRUE,
    p=.50, g1=0, r21=0,
    n, J)
```

```r
power.bira2c1(es=.25, alpha=.05, two.tailed=TRUE,
    p=.50, g1=0, r21=0,
    n, J)
```

```r
mrss.bira2c1(es=.25, power=.80, alpha=.05, two.tailed=TRUE,
    n, J0=10, tol=.10,
    p=.50, g1=0, r21=0)
```

Arguments

- `power`: statistical power \((1 - \beta)\).
- `es`: effect size.
- `alpha`: probability of type I error.
- `two.tailed`: logical; `TRUE` for two-tailed hypothesis testing, `FALSE` for one-tailed hypothesis testing.
- `p`: average proportion of level 1 units randomly assigned to treatment within level 2 units.
- `g1`: number of covariates at level 1.
- `r21`: proportion of level 1 variance in the outcome explained by level 1 covariates.
- `n`: harmonic mean of level 1 units across level 2 units (or simple average).
- `J`: level 2 sample size.
- `J0`: starting value for \(J\).
- `tol`: tolerance to end iterative process for finding \(J\).

Value

- `fun`: function name.
- `parms`: list of parameters used in power calculation.
- `df`: degrees of freedom.
- `ncp`: noncentrality parameter.
- `power`: statistical power \((1 - \beta)\).
- `mdes`: minimum detectable effect size.
- `J`: number of level 2 units.

Examples

```r
# cross-checks
mdes.bira2c1(n=15, J=20)
power.bira2c1(es=.325, n=15, J=20)
mrss.bira2c1(es=.325, n=15)
```
### Description

Use `mdes.bira2f1()` to calculate the minimum detectable effect size, `power.bira2f1()` to calculate the statistical power, and `mrss.bira2f1()` to calculate the minimum required sample size.

### Usage

```r
mdes.bira2f1(power=.80, alpha=.05, two.tailed=TRUE,
              p=.50, g1=0, r21=0, n, J)
```

```r
power.bira2f1(es=.25, alpha=.05, two.tailed=TRUE,
               p=.50, g1=0, r21=0, n, J)
```

```r
mrss.bira2f1(es=.25, power=.80, alpha=.05, two.tailed=TRUE,
             n, J0=10, tol=.10,
             p=.50, g1=0, r21=0)
```

### Arguments

- **power**: statistical power \((1 - \beta)\).
- **es**: effect size.
- **alpha**: probability of type I error.
- **two.tailed**: logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
- **p**: average proportion of level 1 units randomly assigned to treatment within level 2 units.
- **g1**: number of covariates at level 1.
- **r21**: proportion of level 1 variance in the outcome explained by level 1 covariates.
- **n**: harmonic mean of level 1 units across level 2 units (or simple average).
- **J**: level 2 sample size.
- **J0**: starting value for \(J\).
- **tol**: tolerance to end iterative process for finding \(J\).

### Value

- **fun**: function name.
- **parms**: list of parameters used in power calculation.
- **df**: degrees of freedom.
- **ncp**: noncentrality parameter.
power  
minimum detectable effect size.

Examples

# cross-checks
mdes.bira2r1(n=15, J=20)

power.bira2r1(es=.325, n=15, J=20)

mrss.bira2r1(es=.325, n=15)

bira2r1  
Two-Level Blocked Individual-level Random Assignment Design, Treatment at Level 1

Description

Use mdes.bira2r1() to calculate the minimum detectable effect size, power.bira2r1() to calculate the statistical power, and mrss.bira2r1() to calculate the minimum required sample size.

Usage

mdes.bira2r1(power=.80, alpha=.05, two.tailed=TRUE, 
rho2, omega2, p=.50, g2=0, r21=0, r2t2=0, 
n, J)

power.bira2r1(es=.25, alpha=.05, two.tailed=TRUE, 
rho2, omega2, g2=0, p=.50, r21=0, r2t2=0, 
n, J)

mrss.bira2r1(es=.25, power=.80, alpha=.05, two.tailed=TRUE, 
n, J0=10, tol=.10, 
rho2, omega2, g2=0, p=.50, r21=0, r2t2=0)

Arguments

power  
statistical power \((1 - \beta)\).

es  
effect size.

alpha  
probability of type I error.

two.tailed  
logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.

rho2  
proportion of variance in the outcome between level 2 units (unconditional ICC2).

omega2  
treatment effect heterogeneity as ratio of treatment effect variance among level 2 units to the residual variance at level 2.

p  
average proportion of level 1 units randomly assigned to treatment within level 2 units.
g2  number of covariates at level 2.
\( r_{21} \) proportion of level 1 variance in the outcome explained by level 1 covariates.
\( r_{2t2} \) proportion of treatment effect variance among level 2 units explained by level 2 covariates.
n harmonic mean of level 1 units across level 2 units (or simple average).
J level 2 sample size.
J0 starting value for J.
tol tolerance to end iterative process for finding J.

Value

- fun function name.
- parms list of parameters used in power calculation.
- df degrees of freedom.
- ncp noncentrality parameter.
- power statistical power \((1 - \beta)\).
- mdes minimum detectable effect size.
- J number of level 2 units.

See Also
cosa.bird2r1

Examples

# cross-checks
mdes.bira2r1(rho=.17, omega2=.50, n=15, J=20)
power.bira2r1(es=.366, rho2=.17, omega2=.50, n=15, J=20)
mrss.bira2r1(es=.366, rho2=.17, omega2=.50, n=15)

Three-Level Blocked Individual-level Random Assignment Design, Treatment at Level 1

Description

Use mdes.bira3r1() to calculate the minimum detectable effect size, power.bira3r1() to calculate the statistical power, and mrss.bira3r1() to calculate the minimum required sample size.
Usage

mdes.bira3r1(power=.80, alpha=.05, two.tailed=TRUE, rho2, rho3, omega2, omega3, p=.50, r21=0, r2t2=0, r2t3=0, g3=0, n, J, K)

power.bira3r1(es=.25, alpha=.05, two.tailed=TRUE, rho2, rho3, omega2, omega3, p=.50, r21=0, r2t2=0, r2t3=0, g3=0, n, J, K)

mrss.bira3r1(es=.25, power=.80, alpha=.05, two.tailed=TRUE, n, J, K0=10, tol=.10, rho2, rho3, omega2, omega3, p=.50, r21=0, r2t2=0, r2t3=0, g3=0)

Arguments

power  statistical power \((1 - \beta)\).

es  effect size.

alpha  probability of type I error.

two.tailed  logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.

rho2  proportion of variance in the outcome between level 2 units (unconditional ICC2).

rho3  proportion of variance in the outcome between level 3 units (unconditional ICC3).

omega2  treatment effect heterogeneity as ratio of treatment effect variance among level 2 units to the residual variance at level 2.

omega3  treatment effect heterogeneity as ratio of treatment effect variance among level 3 units to the residual variance at level 3.

p  average proportion of level 1 units randomly assigned to treatment within level 2 units.

g3  number of covariates at level 3.

r21  proportion of level 1 variance in the outcome explained by level 1 covariates.

r2t2  proportion of treatment effect variance among level 2 units explained by level 2 covariates.

r2t3  proportion of treatment effect variance among level 3 units explained by level 3 covariates.

n  harmonic mean of level 1 units across level 2 units (or simple average).

J  harmonic mean of level 2 units across level 3 units (or simple average).

K  number of level 3 units.

K0  starting value for K.

tol  tolerance to end iterative process for finding K.
Value

- fun: function name.
- params: list of parameters used in power calculation.
- df: degrees of freedom.
- ncp: noncentrality parameter.
- power: statistical power \( (1 - \beta) \).
- mdes: minimum detectable effect size.
- K: number of level 3 units.

See Also

cosa.bird3r1

Examples

```r
# cross-checks
mdes.bira3r1(rhoS=.20, rho2=.15,
        omegaS=.10, omega2=.10,
        n=69, J=10, K=100)
power.bira3r1(es = .045, rhoS=.20, rho2=.15,
        omegaS=.10, omega2=.10,
        n=69, J=10, K=100)
mrss.bira3r1(es = .045, rhoS=.20, rho2=.15,
        omegaS=.10, omega2=.10,
        n=69, J=10)
```

bira4r1

*Four-Level Blocked Individual-level Random Assignment Design, Treatment at Level 1*

Description

Use `mdes.bira4r1()` to calculate the minimum detectable effect size, `power.bira4r1()` to calculate the statistical power, and `mrss.bira4r1()` to calculate the minimum required sample size.

Usage

```r
mdes.bira4r1(power=.80, alpha=.05, two.tailed=TRUE,
        rho2, rho3, rho4, omega2, omega3, omega4,
        p=.50, r21=0, r2t2=0, r2t3=0, r2t4=0, g4=0,
        n, J, K, L)
```

```r
power.bira4r1(es=.25, alpha=.05, two.tailed=TRUE,
        rho2, rho3, rho4, omega2, omega3, omega4,
        p=.50, r21=0, r2t2=0, r2t3=0, r2t4=0, g4=0,
        n, J, K, L)
```
mrss.bira4r1(es=.25, power=.80, alpha=.05, two.tailed=TRUE, 
n, J, K, L0=10, tol=.10,  
rho2, rho3, rho4, omega2, omega3, omega4, 
p=.50, r2t1=0, r2t2=0, r2t3=0, r2t4=0, g4=0)

Arguments

power           statistical power \((1 - \beta)\).
es              effect size.
alpha           probability of type I error.
two.tailed      logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
rho2            proportion of variance in the outcome between level 2 units (unconditional ICC2).
rho3            proportion of variance in the outcome between level 3 units (unconditional ICC3).
rho4            proportion of variance in the outcome between level 4 units (unconditional ICC4).
omega2          treatment effect heterogeneity as ratio of treatment effect variance among level 2 units to the residual variance at level 2.
omega3          treatment effect heterogeneity as ratio of treatment effect variance among level 3 units to the residual variance at level 3.
omega4          treatment effect heterogeneity as ratio of treatment effect variance among level 4 units to the residual variance at level 4.
p              average proportion of level 1 units randomly assigned to treatment within level 2 units.
g4              number of covariates at level 4.
r21             proportion of level 1 variance in the outcome explained by level 1 covariates.
r2t2            proportion of treatment effect variance among level 2 units explained by level 2 covariates.
r2t3            proportion of treatment effect variance among level 3 units explained by level 3 covariates.
r2t4            proportion of treatment effect variance among level 4 units explained by level 4 covariates.
n              harmonic mean of level 1 units across level 2 units (or simple average).
J              harmonic mean of level 2 units across level 3 units (or simple average).
K              harmonic mean of level 3 units across level 4 units (or simple average).
L              number of level 4 units.
L0              starting value for L.
tol             tolerance to end iterative process for finding L.
Value

fun function name.
params list of parameters used in power calculation.
df degrees of freedom.
ncp noncentrality parameter.
power statistical power \((1 - \beta)\).
mdes minimum detectable effect size.
L number of level 4 units.

See Also

cosa.bird4r1

Examples

# cross-checks
mdes.bira4r1(rho4=.05, rho3=.15, rho2=.15,
omega4=.50, omega3=.50, omega2=.50,
n=10, J=4, K=4, L=27)
power.bira4r1(es = 0.142, rho4=.05, rho3=.15, rho2=.15,
omega4=.50, omega3=.50, omega2=.50,
n=10, J=4, K=4, L=27)
mrss.bira4r1(es = 0.142, rho4=.05, rho3=.15, rho2=.15,
omega4=.50, omega3=.50, omega2=.50,
n=10, J=4, K=4)

Object Conversion

Description

Use mrss.to.mdes() to convert an object returned from MRSS functions into an object returned from MDES functions, mrss.to.power() to convert an object returned from MRSS functions into an object returned from power functions, power.to.mdes() to convert an object returned from power functions into an object returned from MDES functions, mdes.to.power() to convert an object returned from MDES functions into an object returned from power functions, and mdes.to.pctl() to convert effect sizes or an object returned from MDES functions into percentiles.

Usage

mrss.to.mdes(object)
mrss.to.power(object)
power.to.mdes(object)
mdes.to.power(object)
mdes.to.pctl(object)
Arguments

object  an object returned from one of the functions in \textbf{PowerUpR} package.

Examples

design1 <- power.bira2r1(es=.15, rho2=.35, omega2=.10, n=83, J=10)
design2 <- power.to.mdes(design1)
mdes.to.pctl(design2)

cra2r2 \hspace{1cm} Two-level Cluster-randomized Trials to Detect Main, Moderation and Mediation Effects

Description

Use \texttt{mdes.}\<\texttt{design}>() to calculate minimum detectable effect size for the main effect, \texttt{mdesd.}\<\texttt{design}>() to calculate minimum detectable effect size difference for the moderation effect, \texttt{power.}\<\texttt{design}>() to calculate the statistical power, and \texttt{mrss.}\<\texttt{design}>() to calculate the minimum required sample size. Use \texttt{<output>.cra2r2()} for the main effect, \texttt{<output>.mod221()} for the moderator at level 1, \texttt{<output>.mod222()} for the moderator at level 2. Use \texttt{power.med221()} for 2-1-1 mediation, and \texttt{power.med222()} for 2-2-1 mediation.

Usage

\begin{verbatim}
mdes.cra2r2(power=.80, alpha=.05, two.tailed=TRUE, 
  rho2, p=.50, g2=0, r21=0, r22=0, 
  n, J)
mdesd.mod221(power=.80, alpha=.05, two.tailed=TRUE, 
  rho2, omega2, g1=0, r21=0, r2m2=0, 
  p=.50, q=NULL, n, J)
mdesd.mod222(power=.80, alpha=.05, two.tailed=TRUE, 
  rho2, g2=0, r21=0, r22=0, 
  p=.50, q=NULL, n, J)
power.cra2r2(es=.25, alpha=.05, two.tailed=TRUE, 
  rho2, g2=0, p=.50, r21=0, r22=0, 
  n, J)
power.mod221(es=.25, alpha=.05, two.tailed=TRUE, 
  rho2, omega2, g1=0, r21=0, r2m2=0, 
  p=.50, q=NULL, n, J)
power.mod222(es=.25, alpha=.05, two.tailed=TRUE, 
  rho2, g2=0, r21=0, r22=0, 
  p=.50, q=NULL, n, J)
\end{verbatim}
power.med211(esa, esb1, esb, escp, two.tailed = TRUE, alpha = .05, mc = FALSE, nsims = 1000, ndraws = 1000, rhom2, rho2, r21, r22, r2m1, r2m2, p, n, J)

power.med221(esa, esb, escp, two.tailed = TRUE, alpha = .05, mc = FALSE, nsims = 1000, ndraws = 1000, rho2, r22, r21, r2m2, p = .50, n, J)

mrss.cra2r2(es=.25, power=.80, alpha=.05, two.tailed=TRUE, n, J0=10, tol=.10, rho2, g2=0, p=.50, r21=0, r22=0)

mrss.mod221(es=.25, power=.80, alpha=.05, two.tailed=TRUE, n, J0=10, tol=.10, rho2, omegam2, g1=0, r21=0, r2m2=0, p=.50, q=NULL)

mrss.mod222(es=.25, power=.80, alpha=.05, two.tailed=TRUE, n, J0=10, tol=.10, rho2, g2=0, r21=0, r22=0, p=.50, q=NULL)

Arguments

power statistical power \((1 - \beta)\)

es, esa, esb, esb1, esb, escp effect size for main/moderator effects, or for path coefficients a (treatment - mediator), b (level 2 mediator - outcome), b1 (level 1 mediator - outcome), B (overall mediator - outcome) or cp (direct treatment - outcome) in the mediation model.

alpha probability of type I error.

two.tailed logical; FALSE for one-tailed hypothesis testing.

r21 proportion of level 1 variance in the outcome explained by level 1 covariates.
proportion of level 2 variance in the outcome explained by level 2 covariates.

$r2m1$ proportion of mediator variance at level 1 explained by level 1 covariates.

$r2m2$ proportion of variance in the moderator (or mediator) effect that is explained by level 2 predictors. For the mediation model, proportion of mediator variance at level 2 explained by level 2 predictors.

$n$ harmonic mean of level 1 units across level 2 units (or simple average).

$J$ level 2 sample size.

$J0$ starting value for $J$.

tol tolerance to end iterative process for finding $J$.

mc logical; TRUE for monte carlo simulation based power.

nsims number of replications, if mc = TRUE.

ndraws number of draws from the distribution of the path coefficients for each replication, if mc = TRUE.

Value

fun function name.

parms list of parameters used in power calculation.

df degrees of freedom.

ncp noncentrality parameter.

power statistical power $(1 - \beta)$.

mdes minimum detectable effect size.

$J$ number of level 2 units.

See Also

For a more flexible sample size determination see cosa.crd2r2.

Examples

# cross-checks for the main effect
mdes.cra2r2(rho2=.17, n=15, J=20)
power.cra2r2(es=.629, rho2=.17, n=15, J=20)
mrss.cra2r2(es=.629, rho2=.17, n=15)

# cross-checks for the randomly varying cont. L1 moderator effect
mdes.mod221(rho2=.17, omegam2=.10, n=15, J=20)
power.mod221(es=.3563, rho2=.17, omegam2=.10, n=15, J=20)
mrss.mod221(es=.3563, rho2=.17, omegam2=.10, n=15)

# cross-checks for the non-randomly varying cont. L1 moderator effect
mdes.mod221(rho2=.17, omegam2=0, n=15, J=20)
power.mod221(es=0.2957, rho2=.17, omegam2 =0, n=15, J=20)
mrss.mod221(es=0.2957, rho2=.17, omegam2 =0, n=15)

# cross-checks for the randomly varying bin. L1 moderator effect
Three-level Cluster-randomized Trials to Detect Main, Moderation, and Mediation Effects

Description

Use mdes.<design>() to calculate the minimum detectable effect size for the main effect, mdesd.<design>() to calculate the minimum detectable effect size difference for the moderation effect, power.<design>() to calculate the statistical power, and mrss.<design>() to calculate the minimum required sample size. Use <output>.cra3r3() for the main effect, <output>.mod31() for the moderator at level 1, <output>.mod32() for the moderator at level 2, <output>.mod33() for the moderator at level 3. Use power.med31() for 3-2-1 mediation.

Usage

mdes.cra3r3(power=.80, alpha=.05, two.tailed=TRUE,
    rho2, rho3, p=.50, g3=0, r21=0, r22=0, r23=0,
    n, J, K)

mdesd.mod31(power=.80, alpha=.05, two.tailed=TRUE,
rho2, rho3, omegam2=0, omegam3=0,
g1=0, r21=0, r2m2=0, r2m3=0,
p=.50, q=NULL, n, J, K)

mdesd.mod332(power=.80, alpha=.05, two.tailed=TRUE,
rho2, rho3, omegam3, g2=0, r21=0, r22=0, r2m3=0,
p=.50, q=NULL, n, J, K)

mdesd.mod333(power=.80, alpha=.05, two.tailed=TRUE,
rho2, rho3, g3=0, r21=0, r22=0, r23=0,
p=.50, q=NULL, n, J, K)

power.cra3r3(es=.25, alpha=.05, two.tailed=TRUE,
rho2, rho3, g3=0, r21=0, r22=0, r23=0,
p=.50, n, J, K)

power.mod331(es=.25, alpha=.05, two.tailed=TRUE,
rho2, rho3, omegam2, omegam3,
g1=0, r21=0, r2m2=0, r2m3=0,
p=.50, q=NULL, n, J, K)

power.mod332(es=.25, alpha=.05, two.tailed=TRUE,
rho2, rho3, omegam3, g2=0, r21=0, r22=0, r2m3=0,
p=.50, q=NULL, n, J, K)

power.mod333(es=.25, alpha=.05, two.tailed=TRUE,
rho2, rho3, g3=0, r21=0, r22=0, r23=0,
p=.50, q=NULL, n, J, K)

power.med321(esa, esB, two.tailed=TRUE, alpha=.05,
mc=FALSE, nsims=1000, ndraws=1000,
rhomSL, rho2, rho3, r2m2, r2m3, r21, r22, r23,
p=.50, n, J, K)

mrss.cra3r3(es=.25, power=.80, alpha=.05, two.tailed=TRUE,
n, J, K0=10, tol=.10,
rho2, rho3, p=.50, g3=0, r21=0, r22=0, r23=0)

mrss.mod331(es=.25, power=.80, alpha=.05, two.tailed=TRUE,
rho2, rho3, omegam2, omegam3,
g1=0, r21=0, r2m2=0, r2m3=0,
p=.50, q=NULL, n, J, K0=10, tol=.10)

mrss.mod332(es=.25, power=.80, alpha=.05, two.tailed=TRUE,
rho2, rho3, omegam3, g2=0, r21=0, r22=0, r2m3=0,
p=.50, q=NULL, n, J, K0=10, tol=.10)

mrss.mod333(es=.25, power=.80, alpha=.05, two.tailed=TRUE,
Arguments

power statistical power \((1 - \beta)\).

es, esa, esB effect size for main/moderator effects, or for path coefficients a (treatment - mediator), or B (overall mediator - outcome) in the mediation model.

alpha probability of type I error.

two.tailed logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.

rho2 proportion of variance in the outcome between level 2 units (unconditional ICC2).

rho3 proportion of variance in the outcome between level 3 units (unconditional ICC3).

rhom3 proportion of variance in the mediator between level 3 units.

omegam2 ratio of the unconditional variance in the moderator effect that is between level 2 units to the residual variance between level 2 units in the null model.

omegam3 ratio of the unconditional variance in the moderator effect that is between level 3 units to the residual variance between level 3 units in the null model.

p proportion of level 3 units randomly assigned to treatment.

q proportion of level 1, level 2, or level 3 units in the moderator subgroup.

g1 number of covariates at level 1.

g2 number of covariates at level 2.

g3 number of covariates at level 3.

r21 proportion of level 1 variance in the outcome explained by level 1 covariates.

r22 proportion of level 2 variance in the outcome explained by level 2 covariates.

r23 proportion of level 3 variance in the outcome explained by level 3 covariates.

r2m2 proportion of variance in the moderator (or mediator) effect that is explained by level 2 predictors. For the mediation model, proportion of mediator variance at level 2 explained by level 2 predictors.

r2m3 proportion of variance in the moderator (or mediator) effect that is explained by level 3 predictors. For the mediation model, proportion of aggregated mediator variance at level 3 explained by level 3 predictors.

n harmonic mean of level 1 units across level 2 units (or simple average).

J harmonic mean of level 2 units across level 3 units (or simple average).

K level 3 sample size.

K0 starting value for K.

tol tolerance to end iterative process for finding K.

mc logical; TRUE for monte carlo simulation based power.

nsims number of replications, if mc = TRUE.

ndraws number of draws from the distribution of the path coefficients for each replication, if mc = TRUE.
Value

fun  function name.
params  list of parameters used in power calculation.
df  degrees of freedom.
cp  noncentrality parameter.
power  statistical power \((1 - \beta)\).
mdes  minimum detectable effect size.
k  number of level 3 units.

See Also

For a more flexible sample size determination see `cosa.crd3r3`.

Examples

```r
# cross-checks for the main effect
mdes.cra3r3(rhoS=.06, rhoR=.17, n=15, J=3, K=60)
power.cra3r3(es=.269, rhoS=.06, rhoR=.17, n=15, J=3, K=60)
mrss.cra3r3(es=.269, rhoS=.06, rhoR=.17, n=15, J=3)

# cross-checks for the randomly varying cont. L1 moderator effect
mdes.mod31(power=.80, alpha=.05, two.tailed=TRUE,
            rhoR=.17, rhoS=.06, omegam2=.10, omegam3=.10,
            q=NULL, n=15, J=3, K=60)
power.mod31(es=.0.1248, alpha=.05, two.tailed=TRUE,
            rhoR=.17, rhoS=.06, omegam2=.10, omegam3=.10,
            q=NULL, n=15, J=3, K=60)
mrss.mod31(es=.0.1248, alpha=.05, two.tailed=TRUE,
            rhoR=.17, rhoS=.06, omegam2=.10, omegam3=.10,
            q=TRUE, n=15, J=3)

# cross-checks for the non-randomly varying cont. L1 moderator effect
mdesd.mod31(power=.80, alpha=.05, two.tailed=TRUE,
             rhoR=.17, rhoS=.06, omegam2=0, omegam3=0,
             q=TRUE, n=15, J=3, K=60)
power.mod31(es=.0946, alpha=.05, two.tailed=TRUE,
             rhoR=.17, rhoS=.06, omegam2=0, omegam3=0,
             q=TRUE, n=15, J=3, K=60)
mrss.mod31(es=.0946, alpha=.05, two.tailed=TRUE,
             rhoR=.17, rhoS=.06, omegam2=0, omegam3=0,
             q=TRUE, n=15, J=3)

# cross-checks for the randomly varying bin. L1 moderator effect
mdesd.mod31(power=.80, alpha=.05, two.tailed=TRUE,
            rhoR=.17, rhoS=.06, omegam2=.10, omegam3=.10,
            q=.50, n=15, J=3, K=60)
power.mod31(es=.2082, alpha=.05, two.tailed=TRUE,
            rhoR=.17, rhoS=.06, omegam2=.10, omegam3=.10,
            q=.50, n=15, J=3, K=60)
```
Description

use \texttt{mdes.cra4r4()} to calculate the minimum detectable effect size, \texttt{power.cra4r4()} to calculate the statistical power, and \texttt{mrss.cra4r4()} to calculate the minimum required sample size.

Usage

\begin{verbatim}
mdes.cra4r4(power=.80, alpha=.05, two.tailed=TRUE,
             rho2, rho3, rho4, p=.50, r21=0, r22=0, r23=0, r24=0, L)

power.cra4r4(es=.25, alpha=.05, two.tailed=TRUE,
              rho2, rho3, rho4, p=.50, r21=0, r22=0, r23=0, r24=0, L)

mrss.cra4r4(es=.25, power=.80, alpha=.05, two.tailed=TRUE,
             rho2, rho3, rho4, p=.50, r21=0, r22=0, r23=0, r24=0, L)
\end{verbatim}

Arguments

- \texttt{power} \hspace{1cm} statistical power \((1 - \beta)\).
- \texttt{es} \hspace{1cm} effect size.
- \texttt{alpha} \hspace{1cm} probability of type I error.
two.tailed logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.

rho2 proportion of variance in the outcome between level 2 units (unconditional ICC2).

rho3 proportion of variance in the outcome between level 3 units (unconditional ICC3).

rho4 proportion of variance in the outcome between level 4 units (unconditional ICC4).

p proportion of level 4 units randomly assigned to treatment.

g4 number of covariates at level 4.

r21 proportion of level 1 variance in the outcome explained by level 1 covariates.

r22 proportion of level 2 variance in the outcome explained by level 2 covariates.

r23 proportion of level 3 variance in the outcome explained by level 3 covariates.

r24 proportion of level 4 variance in the outcome explained by level 4 covariates.

n harmonic mean of level 1 units across level 2 units (or simple average).

J harmonic mean of level 2 units across level 3 units (or simple average).

K harmonic mean of level 3 units across level 4 units (or simple average).

L number of level 4 units.

L0 starting value for L.

tol tolerance to end iterative process for finding L.

Value

fun function name.

parms list of parameters used in power calculation.

df degrees of freedom.

ncp noncentrality parameter.

power statistical power \( (1 - \beta) \).

mdes minimum detectable effect size.

L number of level 4 units.

See Also
cosa.crd4r4

Examples

# cross-checks
mdes.cra4r4(rho4=.05, rho3=.05, rho2=.10, n=10, J=2, K=3, L=20)
power.cra4r4(es = .412, rho4=.05, rho3=.05, rho2=.10, n=10, J=2, K=3, L=20)
mrss.cra4r4(es = .412, rho4=.05, rho3=.05, rho2=.10, n=10, J=2, K=3)
Description

Use mdes.ira1r1() to calculate minimum detectable effect size, power.ira1r1() to calculate statistical power, and mrss.ira1r1() to calculate minimum required sample size.

Usage

```r
mdes.ira1r1(power=.80, alpha=.05, two.tailed=TRUE,
            p=.50, g1=0, r21=0, n)
```

```r
power.ira1r1(es=.25, alpha=.05, two.tailed=TRUE,
              p=.50, g1=0, r21=0, n)
```

```r
mrss.ira1r1(es=.25, power=.80, alpha=.05, two.tailed=TRUE,
            n0=10, tol=.10,
            p=.50, g1=0, r21=0)
```

Arguments

- `power`: statistical power \((1 - \beta)\).
- `es`: effect size.
- `alpha`: probability of type I error.
- `two.tailed`: logical; TRUE for two-tailed hypothesis testing, FALSE for one-tailed hypothesis testing.
- `p`: proportion of units randomly assigned to treatment.
- `g1`: number of covariates.
- `r21`: proportion of variance in the outcome explained by covariates.
- `n`: sample size.
- `n0`: starting value for `n`.
- `tol`: tolerance to end iterative process for finding `n`.

Value

- `fun`: function name.
- `parms`: list of parameters used in power calculation.
- `df`: degrees of freedom.
- `ncp`: noncentrality parameter.
- `power`: statistical power \((1 - \beta)\).
- `mdes`: minimum detectable effect size.
- `n`: sample size.
See Also

power.ird1r1

Examples

# cross-checks
mdes.ira1r1(n=250)
power.ira1r1(es=.356, n=250)
mrss.ira1r1(es=.356)

Description

Plots statistical power, minimum detectable effect size (MDES), or MDES difference (MDESD) curves with (1-\(\alpha\))x100 % confidence interval.

Usage

```r
## S3 method for class 'power'
plot(x, ypar = "mdes", xpar = NULL,
     xlim = NULL, ylim = NULL,
     xlab = NULL, ylab = NULL,
     main = NULL, sub = NULL,
     locate = FALSE, ...)

## S3 method for class 'mdes'
plot(x, ypar = "mdes", xpar = NULL,
     xlim = NULL, ylim = NULL,
     xlab = NULL, ylab = NULL,
     main = NULL, sub = NULL,
     locate = FALSE, ...)

## S3 method for class 'mrss'
plot(x, ypar = "mdes", xpar = NULL,
     xlim = NULL, ylim = NULL,
     xlab = NULL, ylab = NULL,
     main = NULL, sub = NULL,
     locate = FALSE, ...)
```

Arguments

- `x`: an object returned from one of the `PowerUpR` functions.
- `ypar`: character; "mdes" or "power" on y axis.
- `xpar`: character; one of the sample sizes on x axis.
xlim        limits for xpar.
ylim        limits for ypar.
xlab        x axis label (ignored for objects returned from \codes{power.med211()}, \codes{power.med221()}, and \codes{power.med321()} functions).
ylab        y axis label (ignored for objects returned from \codes{power.med211()}, \codes{power.med221()}, and \codes{power.med321()} functions).
main        title for the plot (ignored for objects returned from \codes{power.med221()} and \codes{power.med211()} functions).
sub         subtitle for the plot (ignored for objects returned from \codes{power.med221()} and \codes{power.med211()} functions).
locate      logical; \TRUE\ locates parameter values for design \(x\) on the plot.
other graphical parameters to pass to \codes{plot.new}().

Examples

\begin{verbatim}
design1 <- mdes.cra3r3(rho3=.06, rho2=.17, n=15, J=3, K=60)
plot(design1, ypar = "mdes", xpar = "K", xlim = c(30, 100))
plot(design1, ypar = "power", xpar = "K", xlim = c(30, 100))

design2 <- power.cra3r3(es=.269, rho3=.06, rho2=.17, n=15, J=3, K=60)
plot(design2, ypar = "mdes", xpar = "K", xlim = c(30, 100))
plot(design2, ypar = "power", xpar = "K", xlim = c(30, 100))
\end{verbatim}

```r

PowerUpR-deprecated

\begin{verbatim}
Deprecated and Defunct functions in \pkg{PowerUpR}

\end{verbatim}

Description

Experimental MDES functions for 2-1-1 and 2-2-1 mediations are removed.

Format

Deprecated or defunct functions are no longer documented.

Details

Defunct functions:

- \codes{mdes.med211} is defunct, there is no replacement function
- \codes{mdes.med221} is defunct, there is no replacement function
Description

t1t2.error plots Type I ($\alpha$) and Type II ($\beta$) error rates using central and noncentral t distributions for any objects returned from one of the PowerUpR functions.

Usage

t1t2.error(object)

Arguments

object an object returned from one of the PowerUpR functions.

Examples

```r
## Not run:

design1 <- mdes.bira2r1(rho2=.35, omega2=.10,
n=83, J=480)
t1t2.error(design1)
```

## End(Not run)
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