Package ‘InteractionPoweR’

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Title Power Analyses for Interaction Effects in Cross-Sectional Regressions

Version 0.2.2

Description Power analysis for regression models which test the interaction of two or three independent variables on a single dependent variable. Includes options for correlated interacting variables and specifying variable reliability. Two-way interactions can include continuous, binary, or ordinal variables. Power analyses can be done either analytically or via simulation. Includes tools for simulating single data sets and visualizing power analysis results. The primary functions are power_interaction_r2() and power_interaction() for two-way interactions, and power_interaction_3way_r2() for three-way interactions.


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BugReports https://github.com/dbaranger/InteractionPoweR/issues

License GPL (>= 3)

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NeedsCompilation no

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compute_adjustment

Description

Computes how much variable correlations need to be adjusted so that they have the desired correlation structure after transformation. Intended for internal use only.

Usage

```
compute_adjustment(
  r.x1.y,
  r.x2.y,
  r.x1x2.y,
  r.x1.x2,
  N.adjustment = 1e+06,
  tol = 0.005,
  iter = 10,
  k.x1,
  k.x2,
  k.y
)
```
Arguments

- `r.x1.y` Internal use only
- `r.x2.y` Internal use only
- `r.x1x2.y` Internal use only
- `r.x1.x2` Internal use only
- `N.adjustment` Internal use only
- `tol` Internal use only
- `iter` Internal use only
- `k.x1` Internal use only
- `k.x2` Internal use only
- `k.y` Internal use only

Value

Correlation adjustments.

Examples

```r
compute_adjustment(r.x1.y = .2, r.x2.y = .2, r.x1x2.y = .1, r.x1.x2 = .2,
                    k.x1 = 0, k.x2 = 0, k.y = 2)
```

Description

Prints or plots the correlation matrix for a 3-way interaction

Usage

```r
cor.mat.3way(power.results, row.num = 1, return.plot = FALSE)
```

Arguments

- `power.results` Data frame of results from `power_interaction_3way_r2()`.
- `row.num` Which row to show? Can only be a single number. Default is 1.
- `return.plot` Return a matrix (FALSE, default), or a plot (TRUE)?

Value

A matrix or a ggplot2 object
Examples

```r
generate_interaction = generate_interaction_3way_r2(detailed_results = TRUE, N = c(1000),
  r.x1.y = .2, r.x2.y = .3, r.x3.y = .1, r.x1x2.y = .01, r.x1x3.y = .05, r.x2x3.y = .1,
  b.x1x2x3 = 0.1, r.x1.x2 = .1, r.x1.x3 = .1, r.x2.x3 = .1,
  rel.x1 = 1, rel.x2 = 1, rel.x3 = 1, rel.y = 1)
generate_interaction_3way(power_analysis)
```

---

generate_interaction_cov.input

*Creates the input to generate_interaction_3way()*

---

**Description**

Companion function to `power_interaction_3way()` . Generates a formatted list for users to specify the analysis parameters.

**Usage**

```r
generate_interaction_cov.input(c.num)
```

**Arguments**

c.num 
Number of covariates in the model.

**Value**

A list to be used with the `generate_interaction_3way()` function.

**Examples**

```r
ex1 = generate_interaction_cov.input(c.num=2)
ex1$correlations$r.y.x1x2 = c(0.1, 0.2, 0.3)
```

---

generate_interaction

*Generate interaction data set*

---

**Description**

Simulate a single data set with an interaction (y ~ x1 + x2 + x1*x2). All values other than 'N' are population-level effects - the values within any single simulated data set will vary around the defined values.
Usage

generate_interaction(
    N,
    r.x1.y,
    r.x2.y,
    r.x1x2.y,
    r.x1.x2,
    rel.x1 = 1,
    rel.x2 = 1,
    rel.y = 1,
    k.x1 = 0,
    k.x2 = 0,
    k.y = 0,
    adjust.correlations = TRUE,
    tol = 0.005,
    iter = 10,
    N.adjustment = 1e+06,
    r.x1.y.adjust = NULL,
    r.x2.y.adjust = NULL,
    r.x1.x2.adjust = NULL,
    r.x1x2.y.adjust = NULL,
    internal.adjust = FALSE,
    skew.x1 = NA,
    skew.x2 = NA,
    skew.y = NA
)

Arguments

  N      Sample size. Must be a positive integer. Has no default value.
  r.x1.y Pearson’s correlation between x1 and y. Must be between -1 and 1. Has no default value.
  r.x2.y Pearson’s correlation between x2 and y. Must be between -1 and 1. Assumed to be the ‘moderator’ in some functions. Has no default value.
  r.x1x2.y Pearson’s correlation between the interaction term x1x2 (x1 * x2) and y. Must be between -1 and 1. Has no default value.
  r.x1.x2 Pearson’s correlation between x1 and x2. Must be between -1 and 1. Has no default value.
  rel.x1 Reliability of x1 (e.g. test-retest reliability, ICC, Cronbach’s alpha). Default is 1 (perfect reliability). Must be greater than 0 and less than or equal to 1.
  rel.x2 Reliability of x2 (e.g. test-retest reliability, ICC, Cronbach’s alpha). Default is 1 (perfect reliability). Must be greater than 0 and less than or equal to 1.
  rel.y Reliability of xy (e.g. test-retest reliability, ICC, Cronbach’s alpha). Default is 1 (perfect reliability). Must be greater than 0 and less than or equal to 1.
  k.x1 Number of discrete values for x1. Can be used to make a variable binary or ordinal.
k.x2    Number of discrete values for x2. Can be used to make a variable binary or ordinal.
k.y     Number of discrete values for y. Can be used to make a variable binary or ordinal.
adjust.correlations
        If variables are ordinal or binary, should correlations be adjusted so that output
data has the specified correlation structure? Default is TRUE.
tol     Correlation adjustment tolerance. When adjust.correlations = TRUE, correlations are adjusted so that the population correlation is within r='tol' of the target. Default = 0.005.
iter    Max number of iterations to run the correlation adjustment for. Typically only a couple are needed. Default = 10.
N.adjustment    Sample size to use when adjusting correlations. Default = 1000000.
r.x1.y.adjust Internal use only.
r.x2.y.adjust Internal use only.
r.x1.x2.adjust Internal use only.
r.x1x2.y.adjust Internal use only.
internal.adjust Internal use only.
skew.x1  No longer supported.
skew.x2  No longer supported.
skew.y   No longer supported.

Value

A data frame containing variables 'x1', 'x2', 'y', and 'x1x2'. 'x1x2' is x1*x2. The correlations between these variables are drawn from the defined population-level values. Output variables are all z-scored (mean=0, sd=1).

Examples

dataset <- generate_interaction(N = 10, r.x1.y = 0, r.x2.y = .1, r.x1x2.y = -.2, r.x1.x2 = .3)

name_key                  Name key for plotting

Description

Expanded variable names so that plots look nicer.

Usage

data(name_key)

Format

A data frame with 25 rows and 2 variables
**Description**

Transforms a vector with a normal distribution to a binomial distribution with two values.

**Usage**

```r
norm2ordinal(x, k)
```

**Arguments**

- `x`: Input vector
- `k`: Number of discrete values (e.g., 2=binary, 5=likert scale)

**Value**

A ordinal or binary variable

**Examples**

```r
norm2ordinal(x = rnorm(n = 100,mean = 0,sd = 1),k=2)
```

---

**plot_interaction**

**Plot interaction**

**Description**

Plots a single simulated interaction data set

**Usage**

```r
plot_interaction(data, q = 3)
```

**Arguments**

- `data`: Output of generate_interaction().
- `q`: Simple slope quantiles. Default is 2. X2 is the default moderator, unless X1 is already binary. Must be a positive integer > 1.

**Value**

A ggplot2 object
Examples

```r
dataset <- generate_interaction(N = 250, r.x1.y = 0, r.x2.y = .1, r.x1x2.y = -.2, r.x1.x2 = .3)
plot_interaction(dataset, q=3)
```

---

### Description

Plot the output of `power_interaction()`.

### Usage

```r
plot_power_curve(
  power_data,
  x = NULL,
  group = NULL,
  facets = NULL,
  power_target = 0.8
)
```

### Arguments

- `power_data`: Data frame of results from `power_interaction()`. Can accept the raw results if up to 3 parameters were varied during simulation. Any more and data should be filtered first.
- `x`: Optional, the x-axis of the plot. Default is the first variable after 'pwr'.
- `group`: Optional, grouping variable for the line color. Default is the second variable after 'pwr', if present.
- `facets`: Optional, grouping variable for plot facets. Default is the third variable after 'pwr' if present.
- `power_target`: The target power. Default is 80%.

### Value

A `ggplot2` object

### Examples

```r
power_analysis <- power_interaction(n.iter = 10, N = seq(100, 300, by=100),
  r.x1.y = 0, r.x2.y = .1, r.x1x2.y = -.2, r.x1.x2 = .3, detailed_results = TRUE)
plot_power_curve(power_analysis)
```
### plot_simple_slope

**Simple slope plot**

#### Description

Plots the simple slope min and max estimates from `power_interaction()`.

#### Usage

```r
plot_simple_slope(power_data, x = NULL, facets = NULL)
```

#### Arguments

- **power_data**
  - Data frame of results from `power_interaction()`. Can accept the raw results if up to 2 parameters were varied during simulation. Any more and data should be filtered first.
- **x**
  - Optional, the x-axis of the plot. Default is the first variable after 'pwr'.
- **facets**
  - Optional, grouping variable for plot facets. Default is the second variable after 'pwr' if present.

#### Value

A ggplot2 object

#### Examples

```r
power_analysis <- power_interaction(n.iter = 10, N = seq(100, 300, by=100),
r.x1.y = 0, r.x2.y = .1, r.x1x2.y = -.2, r.x1.x2 = .3, detailed_results = TRUE)
plot_simple_slope(power_analysis)
```

### power_estimate

**Power estimate**

#### Description

Uses regression to estimate the value needed to attain the target power, given a set of simulation results.

#### Usage

```r
power_estimate(power_data, x, power_target)
```

#### Arguments

- **power_data**
  - Output of `power_interaction()`.
- **x**
  - The name of the target variable as a character string.
- **power_target**
  - The desired power level. Must be between 0 and 1 (e.g., 0.8 for 80% power).
Value

A data frame containing the value of x that achieves the target power for each combination of settings. Will return NA if target power is outside the simulation data.

Examples

```r
simulation_results = power_interaction_r2(N=seq(100,300,by=10),
  r.x1.y=0.2, r.x2.y=.2,r.x1x2.y=0.2,r.x1.x2=.2)
power_estimate(power_data = simulation_results, x = "N", power_target = .8)
```

Description

Power analysis for interaction models, by simulation. A set of n.iter simulations is run for each unique combination of model settings.

Usage

```r
power_interaction(
  n.iter,
  N,
  r.x1.y,
  r.x2.y,
  r.x1x2.y,
  r.x1.x2,
  re1.x1 = 1,
  re1.x2 = 1,
  re1.y = 1,
  k.x1 = 0,
  k.x2 = 0,
  k.y = 0,
  adjust.correlations = TRUE,
  alpha = 0.05,
  q = 2,
  cl = NULL,
  ss.IQR = 1.5,
  N.adjustment = 1e+06,
  detailed_results = FALSE,
  full_simulation = FALSE,
  tol = 0.005,
  iter = 10,
  skew.x1 = NA,
  skew.x2 = NA,
  skew.y = NA
)
```
power_interaction

Arguments

- **n.iter**: Number of iterations. The number of simulations to run for each unique setting combination. Must be a positive integer.

- **N**: Sample size. Must be a positive integer. Has no default value. Can be a single value or a vector of values.

- **r.x1.y**: Pearson’s correlation between x1 and y. Must be between -1 and 1. Has no default value. Can be a single value or a vector of values.

- **r.x2.y**: Pearson’s correlation between x2 and y. Must be between -1 and 1. Assumed to be the ‘moderator’ in some functions. Has no default value. Can be a single value or a vector of values.

- **r.x1x2.y**: Pearson’s correlation between the interaction term x1x2 (x1 * x2) and y. Must be between -1 and 1. Has no default value. Can be a single value or a vector of values.

- **r.x1.x2**: Pearson’s correlation between x1 and x2. Must be between -1 and 1. Has no default value. Can be a single value or a vector of values.

- **rel.x1**: Reliability of x1 (e.g. test-retest reliability, ICC, Cronbach’s alpha). Default is 1 (perfect reliability). Must be greater than 0 and less than or equal to 1.

- **rel.x2**: Reliability of x2 (e.g. test-retest reliability, ICC, Cronbach’s alpha). Default is 1 (perfect reliability). Must be greater than 0 and less than or equal to 1.

- **rel.y**: Reliability of xy (e.g. test-retest reliability, ICC, Cronbach’s alpha). Default is 1 (perfect reliability). Must be greater than 0 and less than or equal to 1.

- **k.x1**: Number of discrete values for x1. Can be used to make a variable binary or ordinal.

- **k.x2**: Number of discrete values for x2. Can be used to make a variable binary or ordinal.

- **k.y**: Number of discrete values for y. Can be used to make a variable binary or ordinal.

- **adjust.correlations**: If variables are ordinal or binary, should correlations be adjusted so that output data has the specified correlation structure? Default is TRUE.

- **alpha**: The alpha. At what p-value is the interaction deemed significant? Default is 0.05.

- **q**: Simple slopes. How many quantiles should x2 be split into for simple slope testing? Default is 2. Simple slope testing returns the effect-size (slope) of y~x1 for the two most extreme quantiles of x2. If q=3 then the two slopes are y~x1 for the bottom 33% of x2, and the top 33% of x2.

- **cl**: Number of clusters to use for running simulations in parallel (recommended). Default is 1 (i.e. not in parallel).

- **ss.IQR**: Simple slope IQR. Multiplier when estimating the distribution of simple slopes within each simulation setting. Default is 1.5.

- **N.adjustment**: Sample size for simulations where correlation matrix is corrected to allow for binary/ordinal variables. Default is 1000000.
detailed_results
Default is FALSE. Should detailed results be reported?

full_simulation
Default is FALSE. If TRUE, will return a list that includes the full per-simulation results.

tol
Correlation adjustment tolerance. When adjust.correlations = TRUE, correlations are adjusted so that the population correlation is within r='tol' of the target. Default = 0.005.

iter
Max number of iterations to run the correlation adjustment for. Typically only a couple are needed. Default = 10.

skew.x1
No longer supported.

skew.x2
No longer supported.

skew.y
No longer supported.

Value
A data frame containing the power (% significant results) for each unique setting combination. If full_simulation = TRUE will return a list, with one data frame that includes power, and a second that includes raw simulation results.

Examples

```r
power_interaction(n.iter=10, N=10, r.x1.y=0.2, r.x2.y=.2, r.x1x2.y=0.5, r.x1.x2=.2)
```

Description
Power analysis for 3-way interaction models, computed via change in R2. Valid for interactions with continuous, normally distributed, variables. Either b.x1x2x3 or f2 can be used to specify the magnitude of the interaction effect size.

Usage

```r
power_interaction_3way_r2(
  N,
  b.x1x2x3,
  r.x1.y,
  r.x2.y,
  r.x3.y,
  r.x1x2.y,
  r.x1x3.y,
  r.x2x3.y,
  r.x1.x2,
)```
Arguments

**N**  
Sample size. Must be a positive integer. Has no default value. Can be a single value or a vector of values.

**b.x1x2x3**  
Regression coefficient of the 3-way interaction term x1x2x3. Should not be specified if \( f2 \) is specified. Must be between -1 and 1. Default is NULL. Can be a single value or a vector of values.

**r.x1.y**  
Pearson’s correlation between x1 and y. Must be between -1 and 1. Has no default value. Can be a single value or a vector of values.

**r.x2.y**  
Pearson’s correlation between x2 and y. Must be between -1 and 1. Assumed to be the ‘moderator’ in some functions. Has no default value. Can be a single value or a vector of values.

**r.x3.y**  
Pearson’s correlation between x3 and y. Must be between -1 and 1. Assumed to be the ‘moderator’ in some functions. Has no default value. Can be a single value or a vector of values.

**r.x1x2.y**  
Pearson’s correlation between the interaction term x1x2 (x1 * x2) and y. Must be between -1 and 1. Has no default value. Can be a single value or a vector of values.

**r.x1x3.y**  
Pearson’s correlation between the interaction term x1x2 (x1 * x3) and y. Must be between -1 and 1. Has no default value. Can be a single value or a vector of values.

**r.x2x3.y**  
Pearson’s correlation between the interaction term x1x2 (x2 * x3) and y. Must be between -1 and 1. Has no default value. Can be a single value or a vector of values.

**r.x1.x2**  
Pearson’s correlation between x1 and x2. Must be between -1 and 1. Has no default value. Can be a single value or a vector of values.

**r.x1.x3**  
Pearson’s correlation between x1 and x3. Must be between -1 and 1. Has no default value. Can be a single value or a vector of values.

**r.x2.x3**  
Pearson’s correlation between x2 and x3. Must be between -1 and 1. Has no default value. Can be a single value or a vector of values.

**rel.x1**  
Reliability of x1 (e.g. test-retest reliability, ICC, Cronbach’s alpha). Default is 1 (perfect reliability). Must be greater than 0 and less than or equal to 1.

**rel.x2**  
Reliability of x2 (e.g. test-retest reliability, ICC, Cronbach’s alpha). Default is 1 (perfect reliability). Must be greater than 0 and less than or equal to 1.
**power_interaction_r2**

Reliability of x3 (e.g. test-retest reliability, ICC, Cronbach’s alpha). Default is 1 (perfect reliability). Must be greater than 0 and less than or equal to 1.

Reliability of xy (e.g. test-retest reliability, ICC, Cronbach’s alpha). Default is 1 (perfect reliability). Must be greater than 0 and less than or equal to 1.

The alpha. At what p-value is the interaction deemed significant? Default is 0.05.

Default is FALSE. Should detailed results be reported? Returns regression slopes, $\mathit{f^2}$, $\mathit{r^2}$, and the full correlation matrix.

Number of clusters to use for running simulations in parallel. Default is NULL (i.e. not in parallel). Useful when running several thousand analyses at once.

A data frame containing the power for each unique setting combination.

**Examples**

```r
power_interaction_3way_r2(N=1000, r.x1.y = .1, r.x2.y = .2, r.x3.y = .3, r.x1x2.y = .05, r.x1x3.y = .07, r.x2x3.y = .09, b.x1x2x3 = .01, r.x1.x2 = .2, r.x1.x3 = .4, r.x2.x3 = .3)
```

**Description**

Power analysis for interaction models, computed via change in $\mathit{R^2}$. Valid for interactions with continuous, normally distributed, variables.

**Usage**

```r
power_interaction_r2(
  N, r.x1.y, r.x2.y, r.x1x2.y, r.x1.x2, rel.x1 = 1, rel.x2 = 1, rel.y = 1, alpha = 0.05, detailed_results = FALSE)
```
Arguments

- **N**: Sample size. Must be a positive integer. Has no default value. Can be a single value or a vector of values.
- **r.x1.y**: Pearson’s correlation between x1 and y. Must be between -1 and 1. Has no default value. Can be a single value or a vector of values.
- **r.x2.y**: Pearson’s correlation between x2 and y. Must be between -1 and 1. Assumed to be the ‘moderator’ in some functions. Has no default value. Can be a single value or a vector of values.
- **r.x1x2.y**: Pearson’s correlation between the interaction term x1x2 (x1 * x2) and y. Must be between -1 and 1. Has no default value. Can be a single value or a vector of values.
- **r.x1.x2**: Pearson’s correlation between x1 and x2. Must be between -1 and 1. Has no default value. Can be a single value or a vector of values.
- **rel.x1**: Reliability of x1 (e.g. test-retest reliability, ICC, Cronbach’s alpha). Default is 1 (perfect reliability). Must be greater than 0 and less than or equal to 1.
- **rel.x2**: Reliability of x2 (e.g. test-retest reliability, ICC, Cronbach’s alpha). Default is 1 (perfect reliability). Must be greater than 0 and less than or equal to 1.
- **rel.y**: Reliability of xy (e.g. test-retest reliability, ICC, Cronbach’s alpha). Default is 1 (perfect reliability). Must be greater than 0 and less than or equal to 1.
- **alpha**: The alpha. At what p-value is the interaction deemed significant? Default is 0.05.
- **detailed_results**: Default is FALSE. Should detailed results be reported?

Value

A data frame containing the power for each unique setting combination.

Examples

```r
taxt power_interaction_r2(N=seq(100,300,by=10),r.x1.y=0.2, r.x2.y=.2,r.x1x2.y=0.2,r.x1.x2=.2)
```

Description

Analytic power analysis of an interaction model with covariates. Additional covariate x main effect interaction terms are additionally added.
Usage

```r
power_interaction_r2_covs(
  cov.input,
  N,
  alpha = 0.05,
  detailed_results = FALSE,
  cl = NULL
)
```

Arguments

cov.input  Output of `power_interaction_r2_covs()`. Variable correlations and reliabilities are set by first modifying this list.

N  Sample size. Must be a positive integer. Has no default value. Can be a single value or a vector of values.

alpha  The alpha. At what p-value is the interaction deemed significant? Default is 0.05.

detailed_results  Default is FALSE. Should detailed results be reported?

cl  Number of clusters to use for running simulations in parallel. Default is NULL (i.e. not in parallel). Useful when running several thousand analyses at once.

Value

A data frame containing the analytic power for each unique setting combination.

Examples

```r
ex1 = generate.interaction.cov.input(c.num=2)
ex1$correlations$r.y.x1x2 = c(0.1,0.2,0.3)
power_interaction_r2_covs(cov.input = ex1,N=100)
```

---

**simple.slopes.3way**  
*See the simple slopes for a 3-way interaction*

Description

Prints or plots the simple slopes for a 3-way interaction

Usage

```
simple.slopes.3way(power.results, row.num = 1, return.plot = FALSE)
```

Arguments

power.results  Data frame of results from `power_interaction_3way_r2()`.

row.num  Which row to show? Can only be a single number. Default is 1.

return.plot  Return a matrix (FALSE, default), or a plot (TRUE)?
Value

A matrix or a ggplot2 object

Examples

```r
data = generate_interaction()

power_analysis = power_interaction_3way_r2(detailed_results = TRUE, N = c(1000),
r.x1.y = .2, r.x2.y = .3, r.x3.y = .1, r.x1x2.y = .01, r.x1x3.y = .05, r.x2x3.y = .1,
b.x1x2x3 = 0.1, r.x1.x2 = .1, r.x1.x3 = .1, r.x2.x3 = .1,
rel.x1 = 1, rel.x2 = 1, rel.x3 = 1, rel.y = 1)
simple.slopes.3way(power_analysis)
```

Description

Test the interaction from a single simulated data set.

Usage

```r
test_interaction(
data, alpha = 0.05, detailed_results = FALSE, q = 2, simple = FALSE)
```

Arguments

data Simulated data set. Output of `generate_interaction()`.
alpha The alpha. At what p-value is the interaction deemed significant? Default is 0.05.
detailed_results Should results beyond the linear model (change in R2, simple slopes, correlations, and confidence intervals) be returned? Default is FALSE.
q Simple slopes. How many quantiles should x2 be split into for simple slope testing? Default is 2. Simple slope testing returns the effect-size (slope) of y~x1 for the two most extreme quantiles of x2. If q=3 then the two slopes are y~x1 for the bottom 33% of x2, and the top 33% of x2.
simple For internal use. Default is FALSE.

Value

Either a named list or a data frame containing the results of the regression y~x1+x2+x1*x2, the pearson’s correlation between y, x1,x2, and x1x2, and the slopes of the simple slopes.
Examples

dataset <- generate_interaction(N = 250, r.x1.y = 0, r.x2.y = .1, r.x1x2.y = -.2, r.x1.x2 = .3)
test_interaction(data = dataset, alpha=0.05, q=2)
Index

compute_adjustment, 2
cor.mat.3way, 3

generate.interaction.cov.input, 4
generate_interaction, 4

name_key, 6
norm2ordinal, 7

plot_interaction, 7
plot_power_curve, 8
plot_simple_slope, 9
power_estimate, 9
power_interaction, 10
power_interaction_3way_r2, 12
power_interaction_r2, 14
power_interaction_r2_covs, 15

simple.slopes.3way, 16

test_interaction, 17