Package ‘JSmediation’

September 3, 2021

**Title**  Mediation Analysis Using Joint Significance

**Version**  0.2.0

**Description**  A set of helper functions to conduct joint-significance tests for mediation analysis, as recommended by Yzerbyt, Muller, Batailler, & Judd. (2018) <doi:10.1037/pspa0000132>.

**License**  MIT + file LICENSE

**URL**  https://jsmediation.cedricbatailler.me/, https://github.com/cedricbatailler/JSmediation

**BugReports**  https://github.com/cedricbatailler/JSmediation/issues

**Depends**  R (>= 2.10)

**Imports**  broom, data.table, dplyr, glue, knitr, magrittr, MASS, purrr, rlang (>= 0.4.9), stats, tibble, utils

**Suggests**  covr, lavaan, markdown, mediation, patchwork, performance, processR, rmarkdown, roxygen2, see (>= 0.6.5), stringr, testthat (>= 3.0.2), vdiff, withr

**VignetteBuilder**  knitr

**ByteCompile**  true

**Config/testthat/edition**  3

**Config/testthat/parallel**  true

**Encoding**  UTF-8

**LazyData**  true

**RoxygenNote**  7.1.1

**NeedsCompilation**  no

**Author**  Cédric Batailler [aut, cre] (<https://orcid.org/0000-0003-0553-6827>), Dominique Muller [aut] (<https://orcid.org/0000-0001-9544-5317>), Vincent Yzerbyt [aut], Charles Judd [aut], Yoann Julliard [ctb] (<https://orcid.org/0000-0002-5428-6994>), Arnold Ho [dtc], Nour Kteily [dtc],
Description

A set of functions to conduct joint-significance tests for mediation analysis.
The main functions of the JSmediation package follow an mdt_* pattern. mdt_* family functions allow you to conduct joint-significance tests for various mediation models (see Judd, Yzerbyt, & Muller, 2014; Muller, Judd, & Yzerbyt, 2005; Yzerbyt, Muller, Batailler, & Judd, 2018).

The syntax for mdt_* family functions is usually the same. The first argument is always a data frame (data) which is followed by the variable names involved in the model (e.g., DV, IV). Because mdt_* family functions use non-standard evaluation, these variable names must generally be specified unquoted.

mdt_* family functions allow you to create an object of class "mediation_model" for which various methods are implemented. The add_index method computes the (moderated) indirect effect index using Monte Carlo for the different mediation models JSmediation offers.

See vignette("jsmediation") for a general introduction and overview of JSmediation.

References


---

**add_index**

*Adds an indirect effect index to a fitted mediation model*

**Description**

`add_index` is a generic function that adds a (moderated) indirect effect index to an object created with an mdt_* family function. This index is computed using Monte Carlo methods. This function invokes particular methods depending of the class of the mediation model. For example, with a model fitted with `mdt_simple`, `add_index` will invoke `add_index.simple_mediation`.

**Usage**

`add_index(mediation_model, times = 5000, level = 0.05, ...)`

**Arguments**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>mediation_model</td>
<td>A mediation model fitted with an mdt_* family function.</td>
</tr>
<tr>
<td>times</td>
<td>Number of simulations to use to compute the Monte Carlo index’s confidence interval.</td>
</tr>
<tr>
<td>level</td>
<td>Alpha threshold to use for the confidence interval.</td>
</tr>
<tr>
<td>...</td>
<td>Further arguments to be passed to specific methods.</td>
</tr>
</tbody>
</table>
add_index.moderated_mediation

Value

An object of the same class as mediation_model, but with index added for later use.

Description

Adds the confidence interval for the index of moderated mediation to a model fitted with mdt_moderated.

Usage

```r
## S3 method for class 'moderated_mediation'
add_index(mediation_model, times = 5000, level = 0.05, stage = NULL, ...)
```

Arguments

- `mediation_model`: A mediation model of class "moderated_mediation".
- `times`: Number of simulations to use to compute the Monte Carlo indirect effect confidence interval.
- `level`: Alpha threshold to use for the confidence interval.
- `stage`: Moderated indirect effect’s stage for which to compute the confidence interval. Can be either 1 (or "first") or 2 (or "second"). To compute total indirect effect moderation index, use "total".
- `...`: Further arguments passed to or from other methods.

Details

Indirect effect moderation index for moderated mediation uses \(a, a \times Mod, b,\) and \(b \times Mod\) estimates and their standard errors to compute the appropriate index product distribution using Monte Carlo methods (see Muller, Judd, & Yzerbyt, 2005).

JSmediation supports different types of mediated indirect effect index:

- **Stage 1**: computes the product between \(a \times Mod\) and \(b\).
- **Stage 2**: computes the product between \(a\) and \(b \times Mod\).
- **Total**: computes the sum of Stage 1 and Stage 2 distribution.

References

Examples

```r
## getting a stage 1 moderated indirect effect index
ho_et_al$condition_c <- build_contrast(ho_et_al$condition,
    "Low discrimination",
    "High discrimination")
ho_et_al <- standardize_variable(ho_et_al, c(linkedfate, sdo), suffix = "c")
moderated_model <- mdt_moderated(data = ho_et_al,
    IV = condition_c,
    DV = hypodescent,
    M = linkedfate_c,
    Mod = sdo_c)
add_index(moderated_model, stage = 1)
```

Description

Adds confidence interval for the index of mediation to a model fitted with `mdt_simple`.

Usage

```r
## S3 method for class 'simple_mediation'
add_index(mediation_model, times = 5000, level = 0.05, ...)
```

Arguments

- `mediation_model`: A mediation model of class "simple_mediation".
- `times`: Number of simulations to use to compute the Monte Carlo indirect effect confidence interval.
- `level`: Alpha threshold to use for the confidence interval.
- `...`: Further arguments passed to or from other methods.

Details

Indirect effect index for simple mediation uses \(a\) and \(b\) estimates and their standard errors to compute the \(ab\) product distribution using Monte Carlo methods (see MacKinnon, Lockwood, & Williams, 2004).

References

add_index.within_participant_mediation

Examples

```r
## getting an indirect effect index
ho_et_al$condition_c <- build_contrast(ho_et_al$condition,
    "Low discrimination",
    "High discrimination")
simple_model <- mdt_simple(data = ho_et_al,
    IV = condition_c,
    DV = hypodescent,
    M = linkedfate)
add_index(simple_model)
```

add_index.within_participant_mediation

---

add_index method for within-participant mediation

Description

Adds the confidence interval for the index of within-participant mediation to a model fitted with `mdt_within` or `mdt_within_wide`.

Usage

```r
## S3 method for class 'within_participant_mediation'
add_index(mediation_model, times = 5000, level = 0.05, ...)
```

Arguments

- `mediation_model` A mediation model of class "within_participant_mediation".
- `times` Number of simulations to use to compute the Monte Carlo indirect effect confidence interval.
- `level` Alpha threshold to use for the confidence interval.
- `...` Further arguments passed to or from other methods.

Details

Indirect effect index for within-participant mediation uses \( a \) and \( b \) estimates and their standard error to compute the \( ab \) product distribution using Monte Carlo methods (see MacKinnon, Lockwood, & Williams, 2004).

References

Examples

```r
## getting an indirect effect index
within_model <- mdt_within(data = dohle_siegrist, 
    IV = name, 
    DV = willingness, 
    M = hazardousness, 
    grouping = participant)
add_index(within_model)
```

Description

Create an APA formatted report from the test of a specific term in a linear model.

Usage

```r
apastylr(model, term)
```

Arguments

- `model` A linear model created using `lm()`.
- `term` A character string representing a term in the linear model.

Value

An APA formatted character string.

Examples

```r
data(ho_et_al)
test <- lm(hypodescent ~ linkedfate, ho_et_al)
apastylr(test, "linkedfate")
```
**build_contrast**

Builds a contrast code from character vector

**Description**

This function constructs a contrast code from a character variable. It is useful when one needs to recode a two-category character variable to a numeric one.

**Usage**

```
build_contrast(vector, cond_a, cond_b)
```

**Arguments**

- `vector`: A character vector.
- `cond_a`: A character string to be coded -0.5.
- `cond_b`: A character string to be coded 0.5.

**Details**

The `lm` method supports factor and character variables by dummy coding them. Dummy coding can make the interpretation of regression coefficient difficult or at least more difficult than contrast coding. Contrast-coded-variable coefficients interpretation is particularly useful when conducting a joint-significance test.

**Value**

A numeric vector.

**See Also**

- `scale` for centering continuous numeric variable.

**Examples**

```r
data(ho_et_al)

ho_et_al$condition_contrast <- build_contrast(ho_et_al$condition, 
   "Low discrimination", 
   "High discrimination")

head(ho_et_al)
```
check\_assumptions

Test assumptions for models underlying the mediation

Description

When conducting a joint-significant test, different models are fitted to the data. This function tests assumptions regarding these models using the performance package.

The assumptions test are performed using check\_normality, check\_heteroscedasticity, and check\_outliers.

Note that check\_assumptions returns a mediation\_model object.

Usage

check\_assumptions(
  mediation\_model,
  tests = c("normality", "heteroscedasticity")
)

Arguments

mediation\_model
  An object of class mediation\_model.

tests
  A character vector indicating which test to run. Supported test includes "normality", "heteroscedasticity", and "outliers"

Value

Invisibly returns an object of class mediation\_model.

See Also

Other assumption checks: plot\_assumptions()

Examples

data(ho\_et\_al)
ho\_et\_al\$condition\_c <- build\_contrast(ho\_et\_al\$condition,
  "Low discrimination",
  "High discrimination")

my\_model <-
  mdt\_simple(data = ho\_et\_al,
  IV = condition\_c,
  DV = hypodescent,
  M = linked\_fate)

check\_assumptions(my\_model)
compute_indirect_effect_for

Compute the indirect effect index for a specific value of the moderator

Description

When computing a moderated mediation, one assesses whether an indirect effect changes according a moderator value (Muller et al., 2005). mdt_moderated makes it easy to assess moderated mediation, but it does not allow accessing the indirect effect for a specific moderator values. compute_indirect_effect_for fills this gap.

Usage

compute_indirect_effect_for(
  mediation_model,
  Mod = 0,
  times = 5000,
  level = 0.05
)

Arguments

mediation_model
  A moderated mediation model fitted with mdt_moderated.

Mod
  The moderator value for which to compute the indirect effect. Must be a numeric value, defaults to 0.

times
  Number of simulations to use to compute the Monte Carlo indirect effect confidence interval. Must be numeric, defaults to 5000.

level
  Alpha threshold to use for the indirect effect’s confidence interval. Defaults to .05.

Details

The approach used by compute_indirect_effect_for is similar to the approach used for simple slope analyses. Specifically, it will fit a new moderated mediation model, but with a data set with a different variable coding. Behind the scenes, compute_indirect_effect_for adjusts the moderator variable coding, so that the value we want to compute the indirect effect for is now 0.

Once done, a new moderated mediation model is applied using the new data set. Because of the new coding, and because of how one interprets coefficients in a linear regression, \( a \times b \) is now the indirect effect we wanted to compute (see the Models section).

Thanks to the returned values of \( a \) and \( b \) (\( b_{01} \) and \( b_{04} \), see the Models section), it is now easy to compute \( a \times b \). compute_indirect_effect_for uses the same approach than the add_index function. A Monte Carlo simulation is used to compute the indirect effect index (MacKinnon et al., 2004).
Models

In a moderated mediation model, three models are used. `compute_indirect_effect_for` uses the same model specification as `mdt_moderated`:

\[
Y_i = b_{40} + b_{41}X_i + b_{42}Mo_i + b_{43}XM_i \\
M_i = b_{50} + b_{51}X_i + b_{52}Mo_i + b_{53}XM_i \\
Y_i = b_{60} + c_{61}X_i + b_{62}Mo_i + b_{63}XM_i + b_{64}Me_i + b_{65}MeMo_i
\]

with \( Y_i \), the outcome value for the \( i \)th observation, \( X_i \), the predictor value for the \( i \)th observation, \( Mo_i \), the moderator value for the \( i \)th observation, and \( M_i \), the mediator value for the \( i \)th observation.

Coefficients associated with \( a \), \( a \times Mod \), \( b \), \( b \times Mod \), \( c \), \( c \times Mod \), \( c' \), and \( c' \times Mod \), paths are respectively \( b_{51}, b_{53}, b_{64}, b_{65}, b_{61}, b_{61}, \) and \( b_{63} \) (see Muller et al., 2005).

References


Examples

```r
# compute an indirect effect index for a specific value in a moderated mediation.
data(ho_et_al)
ho_et_al$condition_c <- build_contrast(ho_et_al$condition, 
  "Low discrimination", 
  "High discrimination")
ho_et_al <- standardize_variable(ho_et_al, c(linkedfate, sdo))
moderated_mediation_model <- mdt_moderated(data = ho_et_al, 
  DV = hypodescent, 
  IV = condition_c, 
  M = linkedfate, 
  Mod = sdo)
compute_indirect_effect_for(moderated_mediation_model, Mod = 0)
```

### Function: `display_models`

**Displays models from a mediation object**

**Description**

When conducting a joint-significance test, different models are fitted to the data. This function helps you see a summary of the models that have been used in an object of class `mediation_model`. 
Usage

display_models(mediation_model)

Arguments

mediation_model

An object of class mediation_model.

Value

A list of summary.lm objects.

Examples

data(ho_et_al)
ho_et_al$condition_c <- build_contrast(ho_et_al$condition,
   "Low discrimination",
   "High discrimination")

my_model <-
  mdt_simple(data = ho_et_al,
             IV = condition_c,
             DV = hypodescent,
             M = linkedfate)

display_models(my_model)

---

dohle_siegrist

Dohle and Siegrist (2014, Exp 1) illustrating within-subject analysis (long-format)

Description

A data set containing data from Dohle and Siegrist (2014)'s Experiment 1 that can be used to conduct within-subject joint-significance test. In this experiment, researchers are interested in the effect of name complexity on willingness to buy a drug. The specific hypothesis is that complex drug names are perceived as more hazardous, which makes someone less likely to buy the drug. Researchers used a within-subject design.

This data set is in a long-format, see mdt_within to conduct a within-participant mediation analysis with this data set.

Usage

data("dohle_siegrist")
**dohe_siegrist_wide**

**Format**

A data frame with 44 rows and 4 variables:

- **participant**  Participant number.
- **name**  Name of the drugs ("simple" vs. "complex").
- **hazardousness**  Mean estimated hazardousness.
- **willingness**  Mean willingness to buy.

**References**


---

**dohle_siegrist_wide**  Dohle and Siegrist (2014, Exp 1) illustrating within-subject analysis (wide-format)

**Description**

A data set containing data from Dohle and Siegrist (2014)’s Experiment 1 that can be used to conduct within-subject joint-significance test. In this experiment, researchers are interested in the effect of name complexity on willingness to buy a drug. The specific hypothesis is that complex drug names are perceived as more hazardous, which makes someone less likely to buy the drug. Researchers used a within-subject design.

This data set is in a wide format, see `mdt_within_wide` to conduct a within-participant mediation analysis with this dataset.

**Usage**

```r
data("dohle_siegrist_wide")
```

**Format**

A data frame with 22 rows and 5 variables:

- **participant**  Participant number.
- **hazardousness_c**  Hazardousness for complex drug name.
- **hazardousness_s**  Hazardousness for simple drug name.
- **willingness_c**  Willingness to buy for complex drug name.
- **willingness_s**  Willingness to buy for simple drug name.

**References**

extract_model

Extracts a single model from a mediation_model object

Description

When conducting a joint-significant test, different models are fitted to the data. This function helps you access the models used in an object of class mediation_model.

Usage

extract_model(mediation_model, step = NULL)

Arguments

mediation_model

An object of class mediation_model.

step

An integer or a string corresponding to the model to extract.

Value

An lm object.

See Also

extract_models to access a list of every model relevant to joint-significance testing.

Other extract functions: extract_models(), extract_tidy_models()

Examples

data(ho_et_al)
ho_et_al$condition_c <- build_contrast(ho_et_al$condition,  
  "Low discrimination",  
  "High discrimination")

my_model <-
  mdt_simple(data = ho_et_al,  
    IV = condition_c,  
    DV = hypodescent,  
    M = linkedfate)

extract_model(my_model, step = "X -> M")
**extract_models**

Extracts models from a mediation_model object

---

**Description**

When conducting a joint-significant test, different models are fitted to the data. This function helps accessing the models used in an object of class `mediation_model`.

**Usage**

```r
extract_models(mediation_model)
```

**Arguments**

- `mediation_model`
  
  An object of class `mediation_model`.

**Value**

A list of `lm` objects.

**See Also**

Other extract functions: `extract_model()`, `extract_tidy_models()`

**Examples**

```r
data(ho_et_al)
ho_et_al$condition_c <- build_contrast(ho_et_al$condition, 
  "Low discrimination", 
  "High discrimination")

my_model <- 
  mdt_simple(data = ho_et_al, 
              IV = condition_c, 
              DV = hypodescent, 
              M = linkedfate)

extract_models(my_model)
```
extract_tidy_models  Extracts models from a mediation object as a data frame

Description

When conducting a joint significant test, different models are fitted to the data. This function helps you access the models used in an object of class mediation_model.

Usage

extract_tidy_models(mediation_model)

Arguments

mediation_model

An object of class mediation_model.

Value

A data frame.

See Also

Other extract functions: extract_models(), extract_model()

Examples

data(ho_et_al)
ho_et_al$condition_c <- build_contrast(ho_et_al$condition,
"Low discrimination",
"High discrimination")

my_model <-
mdt_simple(data = ho_et_al,
IV = condition_c,
DV = hypodescent,
M = linkedfate)

extract_tidy_models(my_model)
Data set showing simple and moderated mediation analysis

Description

A data set containing data from Experiment 3 from Ho, Kteiley, and Chen (2017). In this experiment, the authors hypothesized that presenting a text stating that Black-White biracials were discriminated against would lead Black participants to associate Black-White biracials more with their lower status parent group than their higher status parent group, according to the rule of hypodescent. In this experiment, the authors tested if this effect was mediated by the sense of linked fate between discriminated Black-White biracials and Black participants.

Note that this data set does not include the participants who were in the discrimination control condition in the study conducted by Ho, Kteiley and Chen (2017).

See mdt_simple and mdt_moderated to conduct a simple mediation or a moderated mediation analysis with this dataset.

Usage

data("ho_et_al")

Format

A data frame with 824 rows and 5 variables:

- **id**: An incremental index.
- **condition**: Experimental condition (High discrimination vs. Low discrimination).
- **sdo**: Score at an SDO scale.
- **linkedfate**: Score at an 8-item linked fate measure.
- **hypodescent**: Score at a 3-item measure of hypodescent.

References

**mdt_moderated**

*Fits a moderated mediation model*

**Description**

Given a data frame, a predictor (IV), an outcome (DV), a mediator (M), and a moderator (Mod) conducts a joint-significant test for moderated mediation (see Yzerbyt, Muller, Batailler, & Judd, 2018). You can learn about moderated mediation in vignette("moderated-mediation")

**Usage**

```r
mdt_moderated(data, IV, DV, M, Mod)
```

**Arguments**

- **data**
  - A data frame containing the variables in the model.
- **IV**
  - An unquoted variable in the data frame which will be used as the independent variable.
- **DV**
  - An unquoted variable in the data frame which will be used as the dependent variable.
- **M**
  - An unquoted variable in the data frame which will be used as the mediator.
- **Mod**
  - An unquoted variable in the data frame which will be used as the moderator.

**Details**

With moderated mediation analysis, one tests whether the indirect effect of X on Y through M is moderated by Mod. The hypothesis behind this test is that X has an effect on M (a) which has an effect on Y (b), meaning that X has an indirect effect on Y through M.

Total moderation of the indirect effect of X on Y can be described as follows:

\[ c * Mod = c' * Mod + (a * Mod) * b + a * (b * Mod) \]

with \( c * Mod \) the total moderation of the indirect effect, \( c' * Mod \) the moderation of the direct effect, \( (a * Mod) * b \), the moderation of the indirect effect passing by the moderation of a, and \( a * (b * Mod) \), the moderation of the indirect effect passing by the moderation of b (see Models section; Muller et al., 2005).

Either both \( a * Mod \) and \( b \) or both \( a \) and \( b * Mod \) need to be simultaneously significant for a moderation of the indirect effect to be claimed (Muller et al., 2005).

**Value**

Returns an object of class "mediation_model".

An object of class "mediation_model" is a list containing at least the components:
**mdt_moderated**

- **type**: A character string containing the type of model that has been conducted (e.g., "simple mediation").
- **method**: A character string containing the approach that has been used to conduct the mediation analysis (usually "joint significance").
- **params**: A named list of character strings describing the variables used in the model.
- **paths**: A named list containing information on each relevant path of the mediation model.
- **indirect_index**: A boolean indicating whether an indirect effect index has been computed or not. Defaults to FALSE. See **add_index** to compute mediation index.
- **indirect_index_infos**: (Optional) An object of class "indirect_index". Appears when one applies **add_index** to an object of class "mediation_model".
- **js_models**: A list of objects of class "lm". Contains every model relevant to joint-significance testing.
- **data**: The original data frame that has been passed through the data argument.

**Models**

In a moderated mediation model, three models will be used:

- \( Y_i = b_{40} + b_{41}X_i + b_{42}Mo_i + b_{43}XM_i \)
- \( M_i = b_{50} + b_{51}X_i + b_{52}Mo_i + b_{53}XMo_i \)
- \( Y_i = b_{60} + c'_{61}X_i + b_{62}Mo_i + b_{63}Xmo_i + b_{64}Me_i + b_{65}MeMo_i \)

with \( Y_i \), the outcome value for the \( i \)th observation, \( X_i \), the predictor value for the \( i \)th observation, \( Mo_i \), the moderator value for the \( i \)th observation, and \( M_i \), the mediator value for the \( i \)th observation.

Coefficients associated with \( a \), \( a \times Mod \), \( b \), \( b \times Mod \), \( c \), \( c \times Mod \), \( c' \), and \( c' \times Mod \), paths are respectively \( b_{51}, b_{53}, b_{64}, b_{65}, b_{41}, b_{43}, b_{61}, \) and \( b_{63} \) (see Muller et al., 2005).

**Variable coding**

Because joint-significance tests use linear models behind the scenes, variables involved in the model have to be numeric. **mdt_simple** will give an error if non-numeric variables are specified in the model.

If you need to convert a dichotomous categorical variable to a numeric one, please refer to the **build_contrast** function.

Note that variable coding is especially important in models with multiple predictors as is the case in the model used to conduct a joint-significance test of moderated mediation. Muller et al. (2005) recommend using variables that are either contrast-coded or centered. Using **mdt_moderated** with a DV, a mediator, or a moderator that is neither contrast-coded nor centered will give a warning message.
References


See Also

Other mediation models: `mdt_simple()`, `mdt_within()`

---

**mdt_simple**

*Joint-significance test for simple mediation*

**Description**

Given a data frame, a predictor (IV), an outcome (DV), and a mediator (M), conducts a joint-significant test for simple mediation (see Yzerbyt, Muller, Batailler, & Judd, 2018).

**Usage**

`mdt_simple(data, IV, DV, M)`

**Arguments**

- `data`:
  A data frame containing the variables to be used in the model.

- `IV`:
  An unquoted numeric variable in the data frame which will be used as independent variable.

- `DV`:
  An unquoted numeric variable in the data frame which will be used as dependent variable.

- `M`:
  An unquoted numeric variable in the data frame which will be used as mediator.

**Details**

With simple mediation analysis, one is interested in finding if the effect of $X$ on $Y$ goes through a third variable $M$. The hypothesis behind this test is that $X$ has an effect on $M$ ($a$) that has an effect on $Y$ ($b$), meaning that $X$ has an indirect effect on $Y$ through $M$.

The total effect of $X$ on $Y$ can be described as follows:

$$ c = c' + ab $$

with $c$ the total effect of $X$ on $Y$, $c'$ the direct of $X$ on $Y$, and $ab$ the indirect effect of $X$ on $Y$ through $M$ (see Models section).

To assess whether the indirect effect is different from the null, one has to assess the significance against the null for both $a$ (the effect of $X$ on $M$) and $b$ (effect of $M$ on $Y$ controlling for the effect of $X$). Both $a$ and $b$ need to be simultaneously significant for an indirect effect to be claimed (Cohen & Cohen, 1983; Yzerbyt, Muller, Batailler, & Judd, 2018).
Value

Returns an object of class "mediation_model". An object of class "mediation_model" is a list containing at least the components:

- **type**: A character string containing the type of model that has been conducted (e.g., "simple mediation").
- **method**: A character string containing the approach that has been used to conduct the mediation analysis (usually "joint significance").
- **params**: A named list of character strings describing the variables used in the model.
- **paths**: A named list containing information on each relevant path of the mediation model.
- **indirect_index**: A boolean indicating whether an indirect effect index has been computed or not. Defaults to FALSE. See `add_index` to compute mediation index.
- **indirect_index_infos**: (Optional) An object of class "indirect_index". Appears when one applies `add_index` to an object of class "mediation_model".
- **js_models**: A list of objects of class "lm". Contains every model relevant to joint-significance testing.
- **data**: The original data frame that has been passed through data argument.

Models

In a simple mediation model, three models will be fitted:

- \( Y_i = b_{10} + c_{11}X_i \)
- \( M_i = b_{20} + a_{21}X_i \)
- \( Y_i = b_{30} + c'_{31}X_i + b_{32}M_i \)

with \( Y_i \), the outcome value for the \( i \)th observation, \( X_i \), the predictor value for the \( i \)th observation, and \( M_i \), the mediator value for the \( i \)th observation (Cohen & Cohen, 1983; Yzerbyt, Muller, Batailler, & Judd, 2018).

Coefficients associated with \( a \), \( b \), \( c \), and \( c' \) paths are respectively \( a_{21} \), \( b_{32} \), \( c_{11} \), and \( c'_{31} \).

Variable coding

Because joint-significance tests uses linear models behind the scenes, variables involved in the model have to be numeric. `mdt_simple` will give an error if non-numeric variables are specified in the model.

To convert a dichotomous categorical variable to a numeric one, please refer to the `build_contrast` function.

References


See Also

Other mediation models: `mdt_moderated()`, `mdt_within()`

Examples

```r
## fit a simple mediation model
data(ho_et_al)
ho_et_al$condition_c <- build_contrast(ho_et_al$condition,
                                      "Low discrimination",
                                      "High discrimination")

mdt_simple(data = ho_et_al,
           IV = condition_c,
           DV = hypodescent,
           M = linkedfate)
```

---

**mdt_within**

*Joint-significance test for within-participant mediation*

Description

Given a data frame, a predictor (IV), an outcome (DV), a mediator (M), and a grouping variable (group) conducts a joint-significant test for within-participant mediation (see Yzerbyt, Muller, Batailler, & Judd, 2018).

Usage

```r
mdt_within(data, IV, DV, M, grouping, default_coding = TRUE)
```

Arguments

- **data**: a data frame containing the variables in the model.
- **IV**: an unquoted variable in the data frame which will be used as the independent variable.
- **DV**: an unquoted variable in the data frame which will be used as the dependent variable.
- **M**: an unquoted variable in the data frame which will be used as the mediator.
- **grouping**: an unquoted variable in the data frame which will be used as the grouping variable.
- **default_coding**: should the variable coding be the default? Defaults to TRUE.
Details

With within-participant mediation analysis, one tests whether the effect of \( X \) on \( Y \) goes through a third variable \( M \). The specificity of within-participant mediation analysis lies in the repeated measures design it relies on. With such a design, each sampled unit (e.g., participant) is measured on the dependent variable \( Y \) and the mediator \( M \) in the two conditions of \( X \). The hypothesis behind this test is that \( X \) has an effect on \( M \) \((a)\) which has an effect on \( Y \) \((b)\), meaning that \( X \) has an indirect effect on \( Y \) through \( M \).

As with simple mediation, the total effect of \( X \) on \( Y \) can be conceptually described as follows:

\[ c = c' + ab \]

with \( c \) the total effect of \( X \) on \( Y \), \( c' \) the direct of \( X \) on \( Y \), and \( ab \) the indirect effect of \( X \) on \( Y \) through \( M \) (see Models section).

To assess whether the indirect effect is different from the null, one has to assess the significance against the null for both \( a \) (the effect of \( X \) on \( M \)) and \( b \) (effect of \( M \) on \( Y \) controlling for the effect of \( X \)). Both \( a \) and \( b \) need to be simultaneously significant for an indirect effect to be claimed (Judd, Kenny, & McClelland, 2001; Montoya & Hayes, 2011).

Value

Returns an object of class "mediation_model".

An object of class "mediation_model" is a list containing at least the components:

- **type** A character string containing the type of model that has been conducted (e.g., "simple mediation").
- **method** A character string containing the approach that has been used to conduct the mediation analysis (usually "joint significance").
- **params** A named list of character strings describing the variables used in the model.
- **paths** A named list containing information on each relevant path of the mediation model.
- **indirect_index** A boolean indicating whether an indirect effect index has been computed or not. Defaults to FALSE. See add_index to compute mediation index.
- **indirect_index_infos** (Optional) An object of class "indirect_index". Appears when one applies add_index to an object of class "mediation_model".
- **js_models** A list of objects of class "lm". Contains every model relevant to joint-significance testing.
- **data** The original data frame that has been passed through data argument.

Models

For within-participant mediation, three models will be fitted:

- \( Y_{2i} - Y_{1i} = c_{11} \)
- \( M_{2i} - M_{1i} = a_{21} \)
\[ Y_{2i} - Y_{1i} = c'_{31} + b_{32}(M_{2i} - M_{1i}) + d_{33}[0.5(M_{1i} + M_{2i}) - 0.5(M_1 + M_2)] \]

with \( Y_{2i} - Y_{1i} \) the difference score between DV conditions for the outcome variable for the \( i \)th observation, \( M_{2i} - M_{1i} \) the difference score between DV conditions for the mediator variable for the \( i \)th observation, \( M_{1i} + M_{2i} \) the sum of mediator variables values for DV conditions for the \( i \)th observation, and \( M_1 + M_2 \) the mean sum of mediator variables values for DV conditions across observations (see Montoya & Hayes, 2011).

Coefficients associated with \( a, b, c, \) and \( c' \) paths are respectively \( a_{21}, b_{32}, c_{11}, \) and \( c'_{31} \).

### Data formatting

To be consistent with other mdt_* family functions, mdt_within takes a long-format data frame as data argument. With this kind of format, each sampled unit has two rows, one for the first within-participant condition and one for the second within-participant condition. In addition, each row has one observation for the outcome and one observation for the mediator (see dohle_siegrist for an example.

Because such formatting is not the most common among social scientists interested in within-participant mediation, JSmediation contains the mdt_within_wide function which handles wide-formatted data input (but is syntax-inconsistent with other mdt_* family functions).

### Variable coding

Models underlying within-participant mediation use difference scores as DV (see Models section). Because the function input does not allow the user to specify how the difference scores should be computed, mdt_within has a default coding.

mdt_within’s default behavior is to compute the difference score so the total effect (the effect of \( X \) on \( Y \)) will be positive and compute the other difference scores accordingly. That is, if mdt_within has to use \( Y_{2i} - Y_{1i} \) (instead of \( Y_{1i} - Y_{2i} \)) so that \( c_{11} \) is positive, it will use \( M_{2i} - M_{1i} \) (instead of \( M_{1i} - M_{2i} \)) in the other models.

User can choose to have a negative total effect by using the default_coding argument.

Note that DV and M have to be numeric.

### References


### See Also

Other mediation models: mdt_moderated(), mdt_simple()
Joint-significance test for simple mediation (wide-format input)

Description

Given a data frame, a predictor (IV), an outcome (DV), a mediator (M), and a grouping variable (group) conducts a joint-significant test for within-participant mediation (see Yzerbyt, Muller, Batailler, & Judd, 2018).

Usage

mdt_within_wide(data, DV_A, DV_B, M_A, M_B)

Arguments

data: a data frame containing the variables in the model.
DV_A: an unquoted numeric variable in the data frame which will be used as the dependent variable value for the "A" independent variable condition.
DV_B: an unquoted numeric variable in the data frame which will be used as the dependent variable value for the "B" independent variable condition.
M_A: an unquoted numeric variable in the data frame which will be used as the mediator variable value for the "A" independent variable condition.
M_B: an unquoted numeric variable in the data frame which will be used as the mediator variable value for the "b" independent variable condition.

Details

With within-participant mediation analysis, one tests whether the effect of X on Y goes through a third variable M. The specificity of within-participant mediation analysis lies in the repeated measures design it relies on. With such a design, each sampled unit (e.g., participant) is measured on the dependent variable Y and the mediator M in the two conditions of X. The hypothesis behind this test is that X has an effect on M (a) which has an effect on Y (b), meaning that X has an indirect effect on Y through M.

As with simple mediation, the total effect of X on Y can be conceptually described as follows:

\[ c = c' + ab \]

with \( c \) the total effect of X on Y, \( c' \) the direct of X on Y, and \( ab \) the indirect effect of X on Y through M (see Models section).

To assess whether the indirect effect is different from the null, one has to assess the significance against the null for both a (the effect of X on M) and b (effect of M on Y controlling for the effect of X). Both a and b need to be simultaneously significant for an indirect effect to be claimed (Judd, Kenny, & McClelland, 2001; Montoya & Hayes, 2011).
mdt_within_wide

Value

Returns an object of class "mediation_model".

An object of class "mediation_model" is a list containing at least the components:

- **type**: A character string containing the type of model that has been conducted (e.g., "simple mediation").
- **method**: A character string containing the approach that has been used to conduct the mediation analysis (usually "joint significance").
- **params**: A named list of character strings describing the variables used in the model.
- **paths**: A named list containing information on each relevant path of the mediation model.
- **indirect_index**: A boolean indicating whether an indirect effect index has been computed or not. Defaults to FALSE. See add_index to compute mediation index.
- **indirect_index_infos**: (Optional) An object of class "indirect_index". Appears when one applies add_index to an object of class "mediation_model".
- **js_models**: A list of objects of class "lm". Contains every model relevant to joint-significance testing.
- **data**: The original data frame that has been passed through data argument.

Data formatting

To be consistent with other mdt_* family functions, **mdt_within** takes a long-format data frame as data argument. With this kind of format, each sampled unit has two rows, one for the first within-participant condition and one for the second within-participant condition. In addition, each row has one observation for the outcome and one observation for the mediator (see dohle_siegrist for an example).

Because such formatting is not the most common among social scientists interested in within-participant mediation, JSmediation contains the **mdt_within_wide** function which handles wide-formatted data input (but is syntax-inconsistent with other mdt_* family functions).

Variable coding

Models underlying within-participant mediation use difference scores as DV (see Models section). **mdt_within_wide** uses \(M_A - M_B\) and \(DV_A - DV_B\) in these models.

Models

For within-participant mediation, three models will be fitted:

- \(Y_{2i} - Y_{1i} = c_{11}\)
- \(M_{2i} - M_{1i} = a_{21}\)
- \(Y_{2i} - Y_{1i} = c'_{31} + b_{32}(M_{2i} - M_{1i}) + d_{33}[0.5(M_{1i} + M_{2i}) - 0.5(M_{1} + M_{2})]\)
with $Y_{2i} - Y_{1i}$ the difference score between DV conditions for the outcome variable for the $i$th observation, $M_{2i} - M_{1i}$ the difference score between DV conditions for the mediator variable for the $i$th observation, $M_{1i} + M_{2i}$ the sum of mediator variables values for DV conditions for the $i$th observation, and $M_1 + M_2$ the mean sum of mediator variables values for DV conditions across observations (see Montoya & Hayes, 2011).

Coefficients associated with $a$, $b$, $c$, and $c'$ paths are respectively $a_{21}$, $b_{32}$, $c_{11}$, and $c'_{31}$.

References


---

**plot_assumptions**

Returns diagnostic plots for the linear model used in a mediation

---

**Description**

When conducting a joint-significant test, different models are fitted to the data. This function returns diagnostic plots for each of the model used in the mediation model. `check_assumptions_plot` uses the `performance` and `see` packages behind the scenes to provide the different plots.

This function is best used in an interactive context.

**Usage**

```r
plot_assumptions(
  mediation_model,
  tests = c("normality", "heteroscedasticity", "outliers")
)
```

**Arguments**

- `mediation_model`  
  An object of class `mediation_model`

- `tests`  
  A character vector indicating which test to run. Supported test includes "normality", "heteroscedasticity", and "outliers"

**Value**

Invisibly returns an object of class `mediation_model`.
See Also

Other assumption checks: check_assumptions()

Examples

data(ho_et_al)
ho_et_al$condition_c <- build_contrast(ho_et_al$condition,
   "Low discrimination",
   "High discrimination")

my_model <-
   mdt_simple(data = ho_et_al,
             IV = condition_c,
             DV = hypodescent,
             M = linkedfate)

plot_assumptions(my_model)

print.indirect_index

Description

Print a summary for an indirect effect index created with add_index() method.

Usage

## S3 method for class 'indirect_index'
print(x, digits = 3, ...)

Arguments

x  An object of class indirect_index.
digits  How many significant digits are to be used for numerics.
...  Further arguments.
**print.mediation_model**  
*Print method for object of class mediation_model*

---

### Description

Print a summary for a mediation model represented by a `mediation_model` object.

### Usage

```
## S3 method for class 'mediation_model'
print(x, digits = 3, ...)  
```

### Arguments

- **x**: An object of class `mediation_model`.
- **digits**: How many significant digits are to be used for numerics.
- **...**: Further arguments.

---

**standardize_variable**  
*Standardize variables in a data set.*

---

### Description

`standardize_variable()` standardizes the selected columns in a data frame using `base::scale()`. By default, this function overwrites the column to be scaled. Use the suffix argument to avoid this behavior.

`standardize_variable()` and `standardise_variable()` are synonyms.

### Usage

```
standardize_variable(data, cols = dplyr::everything(), suffix = NULL)
standardise_variable(data, cols = dplyr::everything(), suffix = NULL)
```

### Arguments

- **data**: A data frame containing the variables to standardize.
- **cols**: `<tidy-select>` Columns to standardize. Defaults to `dplyr::everything()`.
- **suffix**: A character suffix to be added to the scaled variables names. When suffix is set to `NULL`, the `standardize_variable()` function will overwrite the scaled variables. Defaults to `NULL`.

### Value

A data frame with the standardized columns.
standardize_variable and grouped_df

Note that standardize_variable ignores grouping. Meaning that if you call this function on a grouped data frame (see dplyr::grouped_df), the overall variables’ mean and standard deviation will be used for the standardization.

Examples

ho_et_al %>%
  standardize_variable(sdo)

ho_et_al %>%
  standardize_variable(c(sdo, linkedfate), suffix = "scaled")
Index

* **assumption checks**
  - check_assumptions, 9
  - plot_assumptions, 27
* **datasets**
  - dohle_siegrist, 12
  - dohle_siegrist_wide, 13
  - ho_et_al, 17
* **extract functions**
  - extract_model, 14
  - extract_models, 15
  - extract_tidy_models, 16
* **mediation models**
  - mdt_moderated, 18
  - mdt_simple, 20
  - mdt_within, 22
  - add_index, 3, 10, 19, 21, 23, 26
  - add_index.moderated_mediation, 4, 18
  - add_index.simple_mediation, 3, 5
  - add_index.within_participant_mediation, 6
  - apastylr, 7
  - base::scale(), 29
  - build_contrast, 8, 19, 21
  - check_assumptions, 9, 28
  - check_heteroscedasticity, 9
  - check_normality, 9
  - check_outliers, 9
  - compute_indirect_effect_for, 10, 18
  - display_models, 11
  - dohle_siegrist, 12, 24, 26
  - dohle_siegrist_wide, 13
  - dplyr::everything(), 29
  - dplyr::grouped_df, 30
  - extract_model, 14, 15, 16
  - extract_models, 14, 15, 16
  - extract_tidy_models, 14, 15, 16
  - ho_et_al, 17
  - JSmediation (JSmediation-package), 2
  - JSmediation-package, 2
  - lm, 8
  - mdt_moderated, 4, 10, 11, 17, 18, 22, 24
  - mdt_simple, 3, 5, 17, 20, 24
  - mdt_within, 6, 12, 20, 22, 24, 26
  - mdt_within_wide, 6, 13, 24, 25, 26
  - plot_assumptions, 9, 27
  - print.indirect_index, 28
  - print.mediation_model, 29
  - scale, 8
  - standardise_variable (standardize_variable), 29
  - standardize_variable, 29

31