Package ‘JSmediation’

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Title Mediation Analysis Using Joint Significance

Version 0.2.2

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>.

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

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

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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

mediation_model
: A mediation model fitted with an `mdt_*` family function.

times
: Number of simulations to use to compute the Monte Carlo index's confidence interval.

level
: Alpha threshold to use for the confidence interval.

...
: Further arguments to be passed to specific methods.

Value

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

---

add_index.moderated_mediation

add_index method for moderated mediation

Description

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

Usage

```
## 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

Muller, D., Judd, C. M., & Yzerbyt, V. Y. (2005). When moderation is mediated and mediation is moderated. *Journal of Personality and Social Psychology*, 89(6), 852-863. doi: 10.1037/0022-3514.89.6.852

Examples

```
## 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)
```

---

add_index.simple_mediation

add_index method for simple mediation

Description

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

Usage

```
## 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

MacKinnon, D. P., Lockwood, C. M., & Williams, J. (2004). Confidence Limits for the Indirect Effect: Distribution of the Product and Resampling Methods. *Multivariate Behavioral Research*, *39*(1), 99-128. doi: 10.1207/s15327906mbr3901_4

Examples

```
## 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

```
## 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

MacKinnon, D. P., Lockwood, C. M., & Williams, J. (2004). Confidence Limits for the Indirect Effect: Distribution of the Product and Resampling Methods. *Multivariate Behavioral Research*, *39*(1), 99-128. doi: 10.1207/s15327906mbr3901_4

Examples

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

---

apastylr *Creates an APA formatted report from a significance test*

Description

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

Usage

```
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

```
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

```
  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 = linkedfate)
```

```
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 ($b_5 1$ and $b_6 4$, 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`:

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

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).

References

MacKinnon, D. P., Lockwood, C. M., & Williams, J. (2004). Confidence Limits for the Indirect Effect: Distribution of the Product and Resampling Methods. *Multivariate Behavioral Research*, *39*(1), 99-128. doi: 10.1207/s15327906mbr3901_4

Muller, D., Judd, C. M., & Yzerbyt, V. Y. (2005). When moderation is mediated and mediation is moderated. *Journal of Personality and Social Psychology*, *89*(6), 852-863. doi: 10.1037/0022-3514.89.6.852

Examples

```
# 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)
```

`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")
```

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, S., & Siegrist, M. (2014). Fluency of pharmaceutical drug names predicts perceived hazardousness, assumed side effects and willingness to buy. *Journal of Health Psychology*, *19*(10), 1241-1249. doi: 10.1177/1359105313488974

`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

```
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

Dohle, S., & Siegrist, M. (2014). Fluency of pharmaceutical drug names predicts perceived hazardousness, assumed side effects and willingness to buy. *Journal of Health Psychology*, *19*(10), 1241-1249. doi: 10.1177/1359105313488974

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

```
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

```
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_model()`, `extract_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_tidy_models(my_model)
```

ho_et_al *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

Ho, A. K., Kteily, N. S., & Chen, J. M. (2017). “You’re one of us”: Black Americans’ use of hypodescent and its association with egalitarianism. *Journal of Personality and Social Psychology*, *113*(5), 753-768. doi: 10.1037/pspi0000107

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")`

`add_index.moderated_mediation` computes the moderated mediation index. `compute_indirect_effect_for` is used to compute the indirect effect index for a specific value of the moderator.

Usage

```
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:

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 moderated mediation model, three models will be used:

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

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

Muller, D., Judd, C. M., & Yzerbyt, V. Y. (2005). When moderation is mediated and mediation is moderated. *Journal of Personality and Social Psychology*, 89(6), 852-863. doi: 10.1037/0022-3514.89.6.852

Yzerbyt, V., Muller, D., Batailler, C., & Judd, C. M. (2018). New recommendations for testing indirect effects in mediational models: The need to report and test component paths. *Journal of Personality and Social Psychology*, *115*(6), 929–943. doi: 10.1037/pspa0000132

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:

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

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

Cohen, J., & Cohen, P. (1983). *Applied multiple regression/correlation analysis for the behavioral sciences* (2nd ed). Hillsdale, N.J: L. Erlbaum Associates.

Yzerbyt, V., Muller, D., Batailler, C., & Judd, C. M. (2018). New recommendations for testing indirect effects in mediational models: The need to report and test component paths. *Journal of Personality and Social Psychology*, *115*(6), 929–943. doi: 10.1037/pspa0000132

See Also

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

Examples

```
## 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

```
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:

- $Y_{2i} - Y_{1i} = c_{11}$
- $M_{2i} - M_{1i} = a_{21}$

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

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 $\overline{M_1 + M_2}$ 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

Judd, C. M., Kenny, D. A., & McClelland, G. H. (2001). Estimating and testing mediation and moderation in within-subject designs. *Psychological Methods*, *6*(2), 115-134. doi: 10.1037//1082-989X.6.2.115

Montoya, A. K., & Hayes, A. F. (2017). Two-condition within-participant statistical mediation analysis: A path-analytic framework. *Psychological Methods*, *22*(1), 6-27. doi: 10.1037/met0000086

Yzerbyt, V., Muller, D., Batailler, C., & Judd, C. M. (2018). New recommendations for testing indirect effects in mediational models: The need to report and test component paths. *Journal of Personality and Social Psychology*, *115*(6), 929–943. doi: 10.1037/pspa0000132

See Also

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

mdt_within_wide *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 mediatior variable value for the "A" independent variable condition.
`M_B`	an unquoted numeric variable in the data frame which will be used as the mediatior 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).

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:

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

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 $\overline{M_1 + M_2}$ 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

Judd, C. M., Kenny, D. A., & McClelland, G. H. (2001). Estimating and testing mediation and moderation in within-subject designs. *Psychological Methods*, *6*(2), 115-134. doi: 10.1037//1082-989X.6.2.115

Montoya, A. K., & Hayes, A. F. (2017). Two-condition within-participant statistical mediation analysis: A path-analytic framework. *Psychological Methods*, *22*(1), 6-27. doi: 10.1037/met0000086

Yzerbyt, V., Muller, D., Batailler, C., & Judd, C. M. (2018). New recommendations for testing indirect effects in mediational models: The need to report and test component paths. *Journal of Personality and Social Psychology*, *115*(6), 929–943. doi: 10.1037/pspa0000132

`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

```
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.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")
```

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