

Package: medfit (via r-universe)

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Type Package

Title Infrastructure for Mediation Model Fitting and Extraction

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Description Provides S7-based infrastructure for fitting mediation models, extracting path coefficients, and performing bootstrap inference. Designed as a foundation package for the mediation analysis ecosystem, supporting 'probmed', 'RMediation', and 'medrobust' packages. Implements unified interfaces for model fitting across different engines (currently generalized linear models, with future support for mixed models and Bayesian methods), standardized extraction of mediation paths from various model types, and robust bootstrap inference methods. Mediation inference methods are described in MacKinnon, Lockwood and Williams (2004) <[doi:10.1207/s15327906mbr3901_4](https://doi.org/10.1207/s15327906mbr3901_4)> and Tofghi and MacKinnon (2011) <[doi:10.3758/s13428-011-0076-x](https://doi.org/10.3758/s13428-011-0076-x)>.

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<https://github.com/data-wise/medfit>

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Author Davood Tofighi [aut, cre] (ORCID:
<https://orcid.org/0000-0001-8523-7776>)
Maintainer Davood Tofighi <dtofighi@gmail.com>
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Contents

| | |
|---|-----------|
| bootstrap_mediation | 2 |
| BootstrapResult | 7 |
| extract_mediation | 9 |
| fit_mediation | 10 |
| med | 13 |
| MediationData | 16 |
| nde | 17 |
| nie | 18 |
| paths | 19 |
| pm | 21 |
| print.mediation_effect | 22 |
| print.summary.BootstrapResult | 22 |
| print.summary.MediationData | 23 |
| print.summary.SerialMediationData | 23 |
| quick | 24 |
| SerialMediationData | 25 |
| te | 28 |
| Index | 30 |

bootstrap_mediation *Perform Bootstrap Inference for Mediation Statistics*

Description

Conduct bootstrap inference to compute confidence intervals for mediation statistics. Supports parametric, nonparametric, and plugin methods.

Conduct bootstrap inference to compute confidence intervals for mediation statistics. Supports parametric, nonparametric, and plugin methods.

Usage

```
bootstrap_mediation(
  statistic_fn,
  method = c("parametric", "nonparametric", "plugin"),
  mediation_data = NULL,
  data = NULL,
  n_boot = 1000L,
  ci_level = 0.95,
  parallel = FALSE,
  ncores = NULL,
  seed = NULL,
  ...
)
```

```
bootstrap_mediation(
  statistic_fn,
  method = c("parametric", "nonparametric", "plugin"),
  mediation_data = NULL,
  data = NULL,
  n_boot = 1000L,
  ci_level = 0.95,
  parallel = FALSE,
  ncores = NULL,
  seed = NULL,
  ...
)
```

Arguments

| | |
|----------------|--|
| statistic_fn | Function that computes the statistic of interest. <ul style="list-style-type: none"> • For parametric bootstrap: receives named parameter vector, returns scalar • For nonparametric bootstrap: receives data frame, returns scalar • For plugin: receives named parameter vector, returns scalar |
| method | Character string: bootstrap method. Options: <ul style="list-style-type: none"> • "parametric": Sample from multivariate normal (fast, assumes normality) • "nonparametric": Resample data and refit (robust, slower) • "plugin": Point estimate only, no CI (fastest) |
| mediation_data | MediationData object (required for parametric/plugin) |
| data | Data frame (required for nonparametric bootstrap) |
| n_boot | Integer: number of bootstrap samples (default: 1000) |
| ci_level | Numeric: confidence level between 0 and 1 (default: 0.95) |
| parallel | Logical: use parallel processing? (default: FALSE) |
| ncores | Integer: number of cores for parallel processing. If NULL, uses <code>parallel::detectCores() - 1</code> |
| seed | Integer: random seed for reproducibility (optional but recommended) |
| ... | Additional arguments (reserved for future use) |

Details

Bootstrap Methods:

Parametric Bootstrap (method = "parametric"):

- Samples parameter vectors from $N(\hat{\theta}, \hat{\Sigma})$
- Fast and efficient
- Assumes asymptotic normality of parameters
- Recommended for most applications with $n > 50$

Nonparametric Bootstrap (method = "nonparametric"):

- Resamples observations with replacement
- Refits models for each bootstrap sample
- More robust, no normality assumption
- Computationally intensive
- Use when normality is questionable or n is small

Plugin Estimator (method = "plugin"):

- Computes point estimate only
- No confidence interval
- Fastest method
- Use for quick checks or when CI not needed

Parallel Processing:

Set `parallel = TRUE` to use multiple cores:

- Automatically detects available cores
- Falls back to sequential if parallel fails
- Seed handling ensures reproducibility

Reproducibility:

Always set a seed for reproducible results:

```
bootstrap_mediation(..., seed = 12345)
```

Bootstrap Methods:

Parametric Bootstrap (method = "parametric"):

- Samples parameter vectors from $N(\hat{\theta}, \hat{\Sigma})$
- Fast and efficient
- Assumes asymptotic normality of parameters
- Recommended for most applications with $n > 50$
- Requires `mediation_data` argument

Nonparametric Bootstrap (method = "nonparametric"):

- Resamples observations with replacement
- Refits models for each bootstrap sample
- More robust, no normality assumption
- Computationally intensive

- Use when normality is questionable or n is small
- Requires data argument

Plugin Estimator (method = "plugin"):

- Computes point estimate only
- No confidence interval
- Fastest method
- Use for quick checks or when CI not needed
- Requires mediation_data argument

Statistic Function:

The statistic_fn should be a function that:

- For parametric/plugin: Takes a named numeric vector of parameters
- For nonparametric: Takes a data frame
- Returns a single numeric value

Common statistic functions for indirect effect:

```
# Using parameter names from MediationData
indirect_fn <- function(theta) {
  theta["m_X"] * theta["y_M"]
}
```

Parallel Processing:

Set parallel = TRUE to use multiple cores:

- Uses parallel::mclapply() on Unix systems
- Falls back to sequential on Windows
- Automatically detects available cores

Reproducibility:

Always set a seed for reproducible results:

```
bootstrap_mediation(..., seed = 12345)
```

Value

A [BootstrapResult](#) object containing:

- Point estimate
- Confidence interval bounds
- Bootstrap distribution (for parametric and nonparametric)
- Method used

A [BootstrapResult](#) object containing:

- Point estimate
- Confidence interval bounds
- Bootstrap distribution (for parametric and nonparametric)
- Method used

See Also

[BootstrapResult](#), [MediationData](#), [extract_mediation\(\)](#)

[BootstrapResult](#), [MediationData](#), [fit_mediation\(\)](#)

Examples

```
## Not run:
# Parametric bootstrap for indirect effect
result <- bootstrap_mediation(
  statistic_fn = function(theta) theta["a"] * theta["b"],
  method = "parametric",
  mediation_data = med_data,
  n_boot = 5000,
  ci_level = 0.95,
  seed = 12345
)

# Nonparametric bootstrap with parallel processing
result <- bootstrap_mediation(
  statistic_fn = function(data) {
    # Refit models and compute statistic
    # ...
  },
  method = "nonparametric",
  data = mydata,
  n_boot = 5000,
  parallel = TRUE,
  seed = 12345
)

# Plugin estimator (no CI)
result <- bootstrap_mediation(
  statistic_fn = function(theta) theta["a"] * theta["b"],
  method = "plugin",
  mediation_data = med_data
)

## End(Not run)

# Generate example data
set.seed(123)
n <- 100
mydata <- data.frame(X = rnorm(n))
mydata$M <- 0.5 * mydata$X + rnorm(n)
mydata$Y <- 0.3 * mydata$X + 0.4 * mydata$M + rnorm(n)

# Fit mediation model
med_data <- fit_mediation(
  formula_y = Y ~ X + M,
  formula_m = M ~ X,
  data = mydata,
  treatment = "X",
```

```
    mediator = "M"
  )

# Define indirect effect function
indirect_fn <- function(theta) theta["m_X"] * theta["y_M"]

# Plugin estimator (point estimate only, fastest)
result_plugin <- bootstrap_mediation(
  statistic_fn = indirect_fn,
  method = "plugin",
  mediation_data = med_data
)
print(result_plugin)

# Parametric bootstrap (recommended for most applications)
result <- bootstrap_mediation(
  statistic_fn = indirect_fn,
  method = "parametric",
  mediation_data = med_data,
  n_boot = 1000,
  ci_level = 0.95,
  seed = 12345
)
print(result)

# Nonparametric bootstrap (slower but more robust)
refit_fn <- function(boot_data) {
  fit_m <- lm(M ~ X, data = boot_data)
  fit_y <- lm(Y ~ X + M, data = boot_data)
  unname(coef(fit_m)["X"] * coef(fit_y)["M"])
}

result_np <- bootstrap_mediation(
  statistic_fn = refit_fn,
  method = "nonparametric",
  data = mydata,
  n_boot = 500,
  seed = 12345
)
print(result_np)
```

Description

S7 class containing results from bootstrap inference, including point estimates, confidence intervals, and bootstrap distribution.

Usage

```

BootstrapResult(
  estimate = integer(0),
  ci_lower = integer(0),
  ci_upper = integer(0),
  ci_level = integer(0),
  boot_estimates = integer(0),
  n_boot = integer(0),
  method = character(0),
  call = quote({
  })
)

```

Arguments

| | |
|----------------|---|
| estimate | Numeric scalar: point estimate of the statistic |
| ci_lower | Numeric scalar: lower bound of confidence interval |
| ci_upper | Numeric scalar: upper bound of confidence interval |
| ci_level | Numeric scalar: confidence level (e.g., 0.95 for 95% CI) |
| boot_estimates | Numeric vector: bootstrap distribution of estimates |
| n_boot | Integer scalar: number of bootstrap samples |
| method | Character scalar: bootstrap method ("parametric", "nonparametric", or "plugin") |
| call | Call object or NULL: original function call |

Details

This class standardizes bootstrap inference results across different bootstrap methods (parametric, nonparametric, plugin).

The class includes validation to ensure consistency between method type and required fields.

Value

A BootstrapResult S7 object

Examples

```

# Parametric bootstrap result
result <- BootstrapResult(
  estimate = 0.15,
  ci_lower = 0.10,
  ci_upper = 0.20,
  ci_level = 0.95,
  boot_estimates = rnorm(1000, 0.15, 0.02),
  n_boot = 1000L,
  method = "parametric",
  call = NULL
)

```

| | |
|-------------------|---|
| extract_mediation | <i>Extract Mediation Structure from Fitted Models</i> |
|-------------------|---|

Description

Generic function to extract mediation structure (a, b, c' paths and variance-covariance matrices) from fitted models. This function provides a unified interface for extracting mediation information from various model types (lm, glm, lavaan, lmer, brms, etc.).

Usage

```
extract_mediation(object, ...)
```

Arguments

| | |
|--------|---|
| object | Fitted model object (lm, glm, lavaan, etc.) |
| ... | Additional arguments passed to methods. Common arguments include: <ul style="list-style-type: none">• treatment: Character string specifying treatment variable name• mediator: Character string specifying mediator variable name• Method-specific arguments (see individual method documentation) |

Details

The `extract_mediation()` generic provides methods for different model types:

- **lm/glm**: Extract from linear and generalized linear models
- **lavaan**: Extract from structural equation models
- **lmerMod**: Extract from mixed-effects models (future)
- **brmsfit**: Extract from Bayesian models (future)

Note: OpenMx extraction is planned for a future release.

All methods return a standardized [MediationData](#) object that can be used with other medfit functions and dependent packages (probmed, RMediation, medrobust).

Value

A [MediationData](#) object containing:

- Path coefficients (a, b, c')
- Full parameter vector and variance-covariance matrix
- Residual variances (for Gaussian models)
- Variable names and metadata
- Original data (if available)

See Also

[MediationData](#), [fit_mediation\(\)](#), [bootstrap_mediation\(\)](#)

Examples

```
# Simulate data with a single mediator (X -> M -> Y)
set.seed(123)
n <- 200
X <- rnorm(n)
M <- 0.5 * X + rnorm(n)
Y <- 0.3 * M + 0.2 * X + rnorm(n)
dat <- data.frame(X = X, M = M, Y = Y)

# Extract the mediation structure from fitted lm models
fit_m <- lm(M ~ X, data = dat)
fit_y <- lm(Y ~ X + M, data = dat)
med_data <- extract_mediation(fit_m, model_y = fit_y,
                             treatment = "X", mediator = "M")
```

 fit_mediation

Fit Mediation Models

Description

Fit mediation models using a specified modeling engine. This function provides a convenient formula-based interface for fitting both the mediator and outcome models simultaneously.

Fit mediation models using a specified modeling engine. This function provides a convenient formula-based interface for fitting both the mediator and outcome models simultaneously.

Usage

```
fit_mediation(
  formula_y,
  formula_m,
  data,
  treatment,
  mediator,
  engine = "glm",
  family_y = stats::gaussian(),
  family_m = stats::gaussian(),
  ...
)

fit_mediation(
  formula_y,
  formula_m,
```

```

    data,
    treatment,
    mediator,
    engine = "glm",
    family_y = stats::gaussian(),
    family_m = stats::gaussian(),
    ...
  )

```

Arguments

| | |
|-----------|--|
| formula_y | Formula for outcome model (e.g., $Y \sim X + M + C$) |
| formula_m | Formula for mediator model (e.g., $M \sim X + C$) |
| data | Data frame containing all variables |
| treatment | Character string: name of treatment variable |
| mediator | Character string: name of mediator variable |
| engine | Character string: modeling engine to use. Currently supports: <ul style="list-style-type: none"> • "glm": Generalized linear models (default) |
| family_y | Family object for outcome model (default: gaussian()) |
| family_m | Family object for mediator model (default: gaussian()) |
| ... | Additional arguments passed to the fitting function |

Details

The `fit_mediation()` function fits both the mediator model and outcome model using the specified engine, then extracts the mediation structure using `extract_mediation()`.

Supported Engines:

GLM (`engine = "glm"`):

- Fits models using `stats::glm()`
- Supports all GLM families (gaussian, binomial, poisson, etc.)
- For Gaussian models, extracts residual variances

Future Engines:

- "lmer": Mixed-effects models via `lme4`
- "brms": Bayesian models via `brms`

Model Specification:

The formulas should follow standard R formula syntax:

- `formula_m`: Mediator model (e.g., $M \sim X + C1 + C2$)
- `formula_y`: Outcome model (e.g., $Y \sim X + M + C1 + C2$)

The mediator must appear in `formula_y`, and the treatment must appear in both formulas.

Model Specification:

The function fits two models:

1. **Mediator model:** formula_m (e.g., $M \sim X + C1 + C2$)
2. **Outcome model:** formula_y (e.g., $Y \sim X + M + C1 + C2$)

The treatment variable must appear in both formulas. The mediator variable must appear in the outcome formula but NOT in the mediator formula (as it is the response).

GLM Engine:

When engine = "glm" (default):

- Models are fit using `stats::glm()`
- Supports all GLM families (gaussian, binomial, poisson, etc.)
- For Gaussian models, residual standard deviations are extracted
- Non-Gaussian outcomes have `sigma_y = NULL`

Common Family Specifications:

- `gaussian()`: Continuous outcomes (default)
- `binomial()`: Binary outcomes
- `poisson()`: Count outcomes
- `Gamma()`: Positive continuous outcomes

Value

A [MediationData](#) object containing the fitted mediation structure

A [MediationData](#) object containing the fitted mediation structure

See Also

[MediationData](#), [extract_mediation\(\)](#), [bootstrap_mediation\(\)](#)

[MediationData](#), [extract_mediation\(\)](#), [bootstrap_mediation\(\)](#)

Examples

```
## Not run:
# Fit Gaussian mediation model
med_data <- fit_mediation(
  formula_y = Y ~ X + M + C,
  formula_m = M ~ X + C,
  data = mydata,
  treatment = "X",
  mediator = "M",
  engine = "glm"
)

# Fit with binary outcome
med_data <- fit_mediation(
  formula_y = Y ~ X + M + C,
  formula_m = M ~ X + C,
  data = mydata,
  treatment = "X",
  mediator = "M",
```

```

    engine = "glm",
    family_y = binomial()
  )

## End(Not run)

# Generate example data
set.seed(123)
n <- 100
mydata <- data.frame(
  X = rnorm(n),
  C = rnorm(n)
)
mydata$M <- 0.5 * mydata$X + 0.2 * mydata$C + rnorm(n)
mydata$Y <- 0.3 * mydata$X + 0.4 * mydata$M + 0.1 * mydata$C + rnorm(n)

# Simple mediation with continuous variables
med_data <- fit_mediation(
  formula_y = Y ~ X + M,
  formula_m = M ~ X,
  data = mydata,
  treatment = "X",
  mediator = "M"
)
print(med_data)

# With covariates
med_data_cov <- fit_mediation(
  formula_y = Y ~ X + M + C,
  formula_m = M ~ X + C,
  data = mydata,
  treatment = "X",
  mediator = "M"
)

# Binary outcome (takes longer to fit)
mydata$Y_bin <- rbinom(n, 1, plogis(0.3 * mydata$X + 0.4 * mydata$M))
med_data_bin <- fit_mediation(
  formula_y = Y_bin ~ X + M,
  formula_m = M ~ X,
  data = mydata,
  treatment = "X",
  mediator = "M",
  family_y = binomial()
)

```

Description

A simplified entry point for mediation analysis. Specify the data and variable names, and get results with minimal configuration.

This is the recommended starting point for most mediation analyses. For more control over model specifications, use `fit_mediation()` directly.

Usage

```
med(
  data,
  treatment,
  mediator,
  outcome,
  covariates = NULL,
  boot = FALSE,
  n_boot = 1000L,
  seed = NULL,
  ...
)
```

Arguments

| | |
|-------------------------|---|
| <code>data</code> | A data frame containing all variables |
| <code>treatment</code> | Character: name of treatment (exposure) variable |
| <code>mediator</code> | Character: name of mediator variable |
| <code>outcome</code> | Character: name of outcome variable |
| <code>covariates</code> | Character vector: names of covariates to include (optional, default: none) |
| <code>boot</code> | Logical: compute bootstrap confidence intervals? (default: FALSE for speed) |
| <code>n_boot</code> | Integer: number of bootstrap samples (default: 1000) |
| <code>seed</code> | Integer: random seed for reproducibility (optional) |
| <code>...</code> | Additional arguments passed to <code>fit_mediation()</code> |

Details

`med()` is designed to be the simplest way to run a mediation analysis. It constructs the model formulas automatically from variable names.

Default Behavior:

- Fits Gaussian (continuous) mediator and outcome models
- No covariates unless specified
- No bootstrap unless requested (use `boot = TRUE`)

Accessing Results:

After running `med()`, use:

- `nie(result)`: Natural indirect effect

- `nde(result)`: Natural direct effect
- `te(result)`: Total effect
- `pm(result)`: Proportion mediated
- `quick(result)`: One-line summary
- `summary(result)`: Detailed summary

Value

A `MediationData` object with mediation results

See Also

`fit_mediation()` for full control, `quick()` for instant summary, `nie()`, `nde()`, `te()`, `pm()` for extracting effects

Examples

```
# Generate example data
set.seed(123)
n <- 200
mydata <- data.frame(
  treatment = rnorm(n),
  covariate = rnorm(n)
)
mydata$mediator <- 0.5 * mydata$treatment + 0.2 * mydata$covariate + rnorm(n)
mydata$outcome <- 0.3 * mydata$treatment + 0.4 * mydata$mediator +
  0.1 * mydata$covariate + rnorm(n)

# Simple mediation (no covariates)
result <- med(
  data = mydata,
  treatment = "treatment",
  mediator = "mediator",
  outcome = "outcome"
)
print(result)

# With covariates
result_cov <- med(
  data = mydata,
  treatment = "treatment",
  mediator = "mediator",
  outcome = "outcome",
  covariates = "covariate"
)

# Quick summary
quick(result)

# With bootstrap CI (slower)
```

```

result_boot <- med(
  data = mydata,
  treatment = "treatment",
  mediator = "mediator",
  outcome = "outcome",
  boot = TRUE,
  n_boot = 1000,
  seed = 42
)

```

MediationData

MediationData S7 Class

Description

S7 class containing standardized mediation model structure, including path coefficients, parameter estimates, variance-covariance matrix, and metadata.

Arguments

| | |
|---------------------|---|
| a_path | Numeric scalar: effect of treatment on mediator (a path) |
| b_path | Numeric scalar: effect of mediator on outcome (b path) |
| c_prime | Numeric scalar: direct effect of treatment on outcome (c' path) |
| estimates | Numeric vector: all parameter estimates |
| vcov | Numeric matrix: variance-covariance matrix of estimates |
| sigma_m | Numeric scalar or NULL: residual SD for mediator model |
| sigma_y | Numeric scalar or NULL: residual SD for outcome model |
| treatment | Character scalar: name of treatment variable |
| mediator | Character scalar: name of mediator variable |
| outcome | Character scalar: name of outcome variable |
| mediator_predictors | Character vector: predictor names in mediator model |
| outcome_predictors | Character vector: predictor names in outcome model |
| data | Data frame or NULL: original data |
| n_obs | Integer scalar: number of observations |
| converged | Logical scalar: whether models converged |
| source_package | Character scalar: package/engine used for fitting |

Details

This class provides a unified container for mediation model information extracted from various model types (lm, glm, lavaan, etc.). It ensures consistency across the mediation analysis ecosystem. The class includes comprehensive validation to ensure data integrity.

Value

A MediationData S7 object

Examples

```
# Create a MediationData object
med_data <- MediationData(
  a_path = 0.5,
  b_path = 0.3,
  c_prime = 0.2,
  estimates = c(0.5, 0.3, 0.2),
  vcov = diag(3) * 0.01,
  sigma_m = 1.0,
  sigma_y = 1.2,
  treatment = "X",
  mediator = "M",
  outcome = "Y",
  mediator_predictors = "X",
  outcome_predictors = c("X", "M"),
  data = NULL,
  n_obs = 100L,
  converged = TRUE,
  source_package = "stats"
)
```

 nde

Extract Natural Direct Effect (NDE)

Description

Extract the natural direct effect from a mediation analysis result. The NDE represents the effect of treatment on outcome that does NOT operate through the mediator.

Usage

```
nde(x, ...)
```

Arguments

x A MediationData, SerialMediationData, or BootstrapResult object
 ... Additional arguments passed to methods

Details

For both simple and serial mediation:

$$NDE = c'$$

where c' is the direct effect coefficient.

Details

For simple mediation (MediationData):

$$NIE = a \times b$$

For serial mediation (SerialMediationData):

$$NIE = a \times d_{21} \times d_{32} \times \dots \times b$$

Value

A numeric value (or named vector for SerialMediationData) with optional attributes for confidence intervals if available

See Also

[nde\(\)](#), [te\(\)](#), [pm\(\)](#), [paths\(\)](#)

Examples

```
# Generate example data
set.seed(123)
n <- 100
mydata <- data.frame(X = rnorm(n))
mydata$M <- 0.5 * mydata$X + rnorm(n)
mydata$Y <- 0.3 * mydata$X + 0.4 * mydata$M + rnorm(n)

med_data <- fit_mediation(
  formula_y = Y ~ X + M,
  formula_m = M ~ X,
  data = mydata,
  treatment = "X",
  mediator = "M"
)

nie(med_data)
```

paths

Extract All Path Coefficients

Description

Extract all path coefficients from a mediation analysis result.

Usage

```
paths(x, ...)
```

Arguments

`x` A `MediationData` or `SerialMediationData` object
`...` Additional arguments passed to methods

Details

For simple mediation (`MediationData`):

- `a`: Treatment -> Mediator (X -> M)
- `b`: Mediator -> Outcome (M -> Y | X)
- `c_prime`: Direct effect (X -> Y | M)

For serial mediation (`SerialMediationData`):

- `a`: Treatment -> First mediator
- `d21, d32, ...`: Mediator-to-mediator paths
- `b`: Last mediator -> Outcome
- `c_prime`: Direct effect

Value

A named numeric vector of path coefficients

See Also

[nie\(\)](#), [nde\(\)](#), [te\(\)](#), [pm\(\)](#)

Examples

```
# Generate example data
set.seed(123)
n <- 100
mydata <- data.frame(X = rnorm(n))
mydata$M <- 0.5 * mydata$X + rnorm(n)
mydata$Y <- 0.3 * mydata$X + 0.4 * mydata$M + rnorm(n)

med_data <- fit_mediation(
  formula_y = Y ~ X + M,
  formula_m = M ~ X,
  data = mydata,
  treatment = "X",
  mediator = "M"
)

paths(med_data)
```

pm *Extract Proportion Mediated (PM)*

Description

Extract the proportion of the total effect that is mediated (operates through the mediator).

Usage

```
pm(x, ...)
```

Arguments

x A MediationData, SerialMediationData, or BootstrapResult object
 ... Additional arguments passed to methods

Details

$$PM = \frac{NIE}{TE} = \frac{NIE}{NIE + NDE}$$

The proportion mediated can be:

- Between 0 and 1: Normal mediation
- Greater than 1: Suppression (direct and indirect effects have opposite signs)
- Negative: Inconsistent mediation

Value

A numeric value between 0 and 1 (or negative/greater than 1 in cases of suppression effects)

See Also

[nie\(\)](#), [nde\(\)](#), [te\(\)](#), [paths\(\)](#)

Examples

```
# Generate example data
set.seed(123)
n <- 100
mydata <- data.frame(X = rnorm(n))
mydata$M <- 0.5 * mydata$X + rnorm(n)
mydata$Y <- 0.3 * mydata$X + 0.4 * mydata$M + rnorm(n)

med_data <- fit_mediation(
  formula_y = Y ~ X + M,
  formula_m = M ~ X,
  data = mydata,
```

```

    treatment = "X",
    mediator = "M"
)

pm(med_data)

```

```
print.mediation_effect
```

Print Method for mediation_effect

Description

Print Method for mediation_effect

Usage

```
## S3 method for class 'mediation_effect'
print(x, ...)
```

Arguments

| | |
|-----|--------------------------------|
| x | A mediation_effect object |
| ... | Additional arguments (ignored) |

Value

Invisibly returns x (the mediation_effect object). Called for its side effect of printing a formatted effect summary to the console.

```
print.summary.BootstrapResult
```

Print Summary for BootstrapResult

Description

Print Summary for BootstrapResult

Usage

```
## S3 method for class 'summary.BootstrapResult'
print(x, ...)
```

Arguments

| | |
|-----|----------------------------------|
| x | A summary.BootstrapResult object |
| ... | Additional arguments (ignored) |

Value

Invisibly returns `x` (the `summary.BootstrapResult` object). Called for its side effect of printing the formatted summary to the console.

```
print.summary.MediationData  
    Print Summary for MediationData
```

Description

Print Summary for MediationData

Usage

```
## S3 method for class 'summary.MediationData'  
print(x, ...)
```

Arguments

| | |
|------------------|---|
| <code>x</code> | A <code>summary.MediationData</code> object |
| <code>...</code> | Additional arguments (ignored) |

Value

Invisibly returns `x` (the `summary.MediationData` object). Called for its side effect of printing the formatted summary to the console.

```
print.summary.SerialMediationData  
    Print Summary for SerialMediationData
```

Description

Print Summary for SerialMediationData

Usage

```
## S3 method for class 'summary.SerialMediationData'  
print(x, ...)
```

Arguments

| | |
|------------------|---|
| <code>x</code> | A <code>summary.SerialMediationData</code> object |
| <code>...</code> | Additional arguments (ignored) |

Value

Invisibly returns `x` (the `summary.SerialMediationData` object). Called for its side effect of printing the formatted summary to the console.

 quick

Quick Summary of Mediation Results

Description

Print a one-line summary of mediation results, perfect for quick checks or ADHD-friendly workflows.

Usage

```
quick(x, digits = 3, ...)
```

Arguments

| | |
|---------------------|--|
| <code>x</code> | A <code>MediationData</code> object (or result from <code>med()</code>) |
| <code>digits</code> | Integer: number of significant digits (default: 3) |
| <code>...</code> | Additional arguments (ignored) |

Details

Prints a compact one-line summary showing:

- NIE (Natural Indirect Effect) with CI if available
- NDE (Natural Direct Effect)
- Proportion Mediated (PM)

If bootstrap results are available (from `med(..., boot = TRUE)`), confidence intervals are shown for NIE.

Value

Invisibly returns `x`

See Also

[med\(\)](#), [nie\(\)](#), [nde\(\)](#), [pm\(\)](#)

Examples

```
# Generate example data
set.seed(123)
n <- 100
mydata <- data.frame(X = rnorm(n))
mydata$M <- 0.5 * mydata$X + rnorm(n)
mydata$Y <- 0.3 * mydata$X + 0.4 * mydata$M + rnorm(n)

result <- med(
  data = mydata,
  treatment = "X",
  mediator = "M",
  outcome = "Y"
)

# One-line summary
quick(result)
```

SerialMediationData *SerialMediationData S7 Class*

Description

S7 class for serial mediation models where the effect flows through multiple mediators in sequence: X → M1 → M2 → ... → Mk → Y.

This class supports serial mediation chains of any length, from simple two-mediator models (product-of-three: $a * d * b$) to complex chains with many mediators (product-of-k).

Arguments

| | |
|-----------------|---|
| a_path | Numeric scalar: effect of treatment on first mediator (X → M1) |
| d_path | Numeric vector: sequential mediator-to-mediator effects <ul style="list-style-type: none"> • For 2 mediators (X → M1 → M2 → Y): scalar d21 (M1 → M2) • For 3 mediators (X → M1 → M2 → M3 → Y): c(d21, d32) • For k mediators: vector of length (k-1) |
| b_path | Numeric scalar: effect of last mediator on outcome (Mk → Y) |
| c_prime | Numeric scalar: direct effect of treatment on outcome (X → Y) |
| estimates | Numeric vector: all parameter estimates |
| vcov | Numeric matrix: variance-covariance matrix of estimates |
| sigma_mediators | Numeric vector or NULL: residual SDs for mediator models. Length should match number of mediators. First element is residual SD for M1 model, second element for M2 model, etc. |
| sigma_y | Numeric scalar or NULL: residual SD for outcome model |

| | |
|---------------------|--|
| treatment | Character scalar: name of treatment variable |
| mediators | Character vector: names of mediators in sequential order. First element is M1, second element is M2, etc. |
| outcome | Character scalar: name of outcome variable |
| mediator_predictors | List of character vectors: predictor names for each mediator model. First list element contains predictors for M1 (typically just "X"), second element contains predictors for M2 (typically c("X", "M1")), etc. |
| outcome_predictors | Character vector: predictor names in outcome model |
| data | Data frame or NULL: original data |
| n_obs | Integer scalar: number of observations |
| converged | Logical scalar: whether all models converged |
| source_package | Character scalar: package/engine used for fitting |

Details

Serial Mediation Structure:

Serial mediation models the indirect effect flowing through a sequence of mediators. The total indirect effect is the product of all path coefficients:

- **2 mediators (product-of-three):** Indirect = $a * d * b$
- **3 mediators (product-of-four):** Indirect = $a * d_{21} * d_{32} * b$
- **k mediators (product-of-k+1):** Indirect = $a * d_{21} * d_{32} * \dots * d_{(k,k-1)} * b$

Path Notation:

- a: Treatment -> First mediator (X -> M1)
- d₂₁: First -> Second mediator (M1 -> M2)
- d₃₂: Second -> Third mediator (M2 -> M3)
- d_{ji}: Previous mediator -> Current mediator
- b: Last mediator -> Outcome (M_k -> Y)
- c': Direct effect (X -> Y, controlling for all mediators)

Extensibility:

This class is designed to handle serial chains of any length:

- Minimal case: 2 mediators (length(d_path) = 1)
- No upper limit on chain length
- Validator ensures consistency between mediators and paths

Value

A SerialMediationData S7 object

Examples

```

# Two-mediator serial mediation (X -> M1 -> M2 -> Y)
# Product-of-three: a * d * b
serial_data <- SerialMediationData(
  a_path = 0.5,      # X -> M1
  d_path = 0.4,      # M1 -> M2 (scalar for 2 mediators)
  b_path = 0.3,      # M2 -> Y
  c_prime = 0.1,     # X -> Y (direct)
  estimates = c(0.5, 0.4, 0.3, 0.1),
  vcov = diag(4) * 0.01,
  sigma_mediators = c(1.0, 1.1), # SD for M1, M2 models
  sigma_y = 1.2,
  treatment = "X",
  mediators = c("M1", "M2"),
  outcome = "Y",
  mediator_predictors = list(
    c("X"),          # M1 ~ X
    c("X", "M1")     # M2 ~ X + M1
  ),
  outcome_predictors = c("X", "M1", "M2"), # Y ~ X + M1 + M2
  data = NULL,
  n_obs = 100L,
  converged = TRUE,
  source_package = "lavaan"
)

# Three-mediator serial mediation (X -> M1 -> M2 -> M3 -> Y)
# Product-of-four: a * d21 * d32 * b
serial_data_3 <- SerialMediationData(
  a_path = 0.5,      # X -> M1
  d_path = c(0.4, 0.35), # M1 -> M2, M2 -> M3 (vector for 3 mediators)
  b_path = 0.3,      # M3 -> Y
  c_prime = 0.1,
  estimates = c(0.5, 0.4, 0.35, 0.3, 0.1),
  vcov = diag(5) * 0.01,
  sigma_mediators = c(1.0, 1.1, 1.05), # SD for M1, M2, M3 models
  sigma_y = 1.2,
  treatment = "X",
  mediators = c("M1", "M2", "M3"),
  outcome = "Y",
  mediator_predictors = list(
    c("X"),          # M1 ~ X
    c("X", "M1"),    # M2 ~ X + M1
    c("X", "M1", "M2") # M3 ~ X + M1 + M2
  ),
  outcome_predictors = c("X", "M1", "M2", "M3"),
  data = NULL,
  n_obs = 100L,
  converged = TRUE,
  source_package = "lavaan"
)

```

te *Extract Total Effect (TE)*

Description

Extract the total effect from a mediation analysis result. The TE is the sum of the indirect and direct effects.

Usage

```
te(x, ...)
```

Arguments

x A MediationData, SerialMediationData, or BootstrapResult object
 ... Additional arguments passed to methods

Details

$$TE = NIE + NDE$$

Value

A numeric value with optional attributes for confidence intervals

See Also

[nie\(\)](#), [nde\(\)](#), [pm\(\)](#), [paths\(\)](#)

Examples

```
# Generate example data
set.seed(123)
n <- 100
mydata <- data.frame(X = rnorm(n))
mydata$M <- 0.5 * mydata$X + rnorm(n)
mydata$Y <- 0.3 * mydata$X + 0.4 * mydata$M + rnorm(n)

med_data <- fit_mediation(
  formula_y = Y ~ X + M,
  formula_m = M ~ X,
  data = mydata,
  treatment = "X",
  mediator = "M"
)
```

```
te(med_data)

# Verify: TE = NIE + NDE
nie(med_data) + nde(med_data)
```

Index

`bootstrap_mediation`, 2
`bootstrap_mediation()`, 10, 12
`BootstrapResult`, 5, 6, 7

`extract_mediation`, 9
`extract_mediation()`, 6, 11, 12

`fit_mediation`, 10
`fit_mediation()`, 6, 10, 14, 15

`med`, 13
`med()`, 24
`MediationData`, 3, 6, 9, 10, 12, 16

`nde`, 17
`nde()`, 15, 19–21, 24, 28
`nie`, 18
`nie()`, 15, 18, 20, 21, 24, 28

`paths`, 19
`paths()`, 18, 19, 21, 28
`pm`, 21
`pm()`, 15, 18–20, 24, 28
`print.mediation_effect`, 22
`print.summary.BootstrapResult`, 22
`print.summary.MediationData`, 23
`print.summary.SerialMediationData`, 23

`quick`, 24
`quick()`, 15

`SerialMediationData`, 25
`stats::glm()`, 12

`te`, 28
`te()`, 15, 18–21