Package ‘altmeta’

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Type Package

Title Alternative Meta-Analysis Methods

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Description Provides alternative statistical methods for meta-analysis, including new heterogeneity tests and measures that are robust to outliers.

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R topics documented:

aex — *A Meta-Analysis for Evaluating the Effect of Aerobic Exercise on Visceral Adipose Tissue Content/Volume*

Description

This meta-analysis serves as an example to illustrate the function usage in the package **altmeta**.

Usage

```
data("aex")
```

Format

A data frame containing 29 studies with the observed effect sizes and their within-study variances.

- `y` The observed effect size for each collected study in the meta-analysis.
- `s2` The within-study variance for each study.

Source

Ismail I, Keating SE, Baker MK, and Johnson NA (2012). "A systematic review and meta-analysis of the effect of aerobic vs resistance exercise training on visceral fat." *Obesity Reviews*, **13**(1), 68–91.

ha — *A Meta-Analysis for Investigating the Effect of Placebo Interventions for All Clinical Conditions Regarding Patient-Reported Outcomes*

Description

This meta-analysis serves as an example to illustrate the function usage in the package **altmeta**.

Usage

```
data("ha")
```

Format

A data frame containing 109 studies with the observed effect sizes and their within-study variances.

- `y` The observed effect size for each collected study in the meta-analysis.
- `s2` The within-study variance for each study.

Source

Hrobjartsson A and Gotzsche PC (2010). "Placebo interventions for all clinical conditions." *Cochrane Database of Systematic Reviews*, **1**. Art No.: CD003974. DOI: 10.1002/14651858.CD003974.pub3.

`hipfrac` *A Meta-Analysis for Investigating the Magnitude and Duration of Excess Mortality After Hip Fracture Among Older Men*

Description

This meta-analysis serves as an example to illustrate the function usage in the package **altmeta**.

Usage

```
data("hipfrac")
```

Format

A data frame containing 17 studies with the observed effect sizes and their within-study variances.

`y` The observed effect size for each collected study in the meta-analysis.

`s2` The within-study variance for each study.

Source

Haentjens P, Magaziner J, Colon-Emeric CS, Vanderschueren D, Milisen K, Velkeniers B, and Boonen S (2010). "Meta-analysis: excess mortality after hip fracture among older women and men". *Annals of Internal Medicine*, **152**(6), 380–390.

`lcj` *A Meta-Analysis for Evaluating the Effect of Progressive Resistance Strength Training Exercise Versus Control*

Description

This meta-analysis serves as an example to illustrate the function usage in the package **altmeta**.

Usage

```
data("lcj")
```

Format

A data frame containing 33 studies with the observed effect sizes and their within-study variances.

`y` The observed effect size for each collected study in the meta-analysis.

`s2` The within-study variance for each study.

Source

Liu CJ and Latham NK (2009). "Progressive resistance strength training for improving physical function in older adults." *Cochrane Database of Systematic Reviews*, **3**. Art No.: CD002759. DOI: 10.1002/14651858.CD002759.pub2.

`metahet` *Meta-Analysis Heterogeneity Measures*

Description

Calculates various between-study heterogeneity measures in meta-analysis, including the conventional measures (e.g., I^2) and the alternative measures (e.g., I_r^2) which are robust to outlying studies; p-values of various tests are also calculated.

Usage

```
metahet(y, s2, n.resam = 1000)
```

Arguments

`y`	a numeric vector indicating the observed effect sizes in the collected studies; they are assumed to be normally distributed.
`s2`	a numeric vector indicating the within-study variances.
`n.resam`	a positive integer indicating the number of resampling iterations for calculating p-values of test statistics and 95% confidence interval of heterogeneity measures.

Details

Suppose that a meta-analysis collects n studies. The observed effect size in study i is y_i and its within-study variance is s_i^2. Also, the inverse-variance weight is $w_i = 1/s_i^2$. The fixed-effect estimate of overall effect size is $\bar{\mu} = \sum_{i=1}^n w_i y_i / \sum_{i=1}^n w_i$. The conventional test statistic for heterogeneity is

$$Q = \sum_{i=1}^{n} w_i (y_i - \bar{\mu})^2.$$

Based on the Q statistic, the method-of-moments estimate of the between-study variance $\hat{\tau}_{DL}^2$ is (DerSimonian and Laird, 1986)

$$\hat{\tau}_{DL}^2 = \max\left\{0, \frac{Q - (n-1)}{\sum_{i=1}^n w_i - \sum_{i=1}^n w_i^2 / \sum_{i=1}^n w_i}\right\}.$$

Also, the H and I^2 statistics (Higgins and Thompson, 2002; Higgins et al., 2003) are widely used in practice because they do not depend on the number of collected studies n and the effect size scale; these two statistics are defined as

$$H = \sqrt{Q/(n-1)};$$

$$I^2 = \frac{Q - (n-1)}{Q}.$$

Specifically, the H statistic reflects the ratio of the standard deviation of the underlying mean from a random-effects meta-analysis compared to the standard deviation from a fixed-effect meta-analysis; the I^2 statistic describes the proportion of total variance across studies that is due to heterogeneity rather than sampling error.

Outliers are frequently present in meta-analysis, and they may have great impact on the above heterogeneity measures. Alternatively, to be more robust to outliers, the test statistic may be modified as (Lin et al., 2016+):

$$Q_r = \sum_{i=1}^{n} \sqrt{w_i}|y_i - \bar{\mu}|.$$

Based on the Q_r statistic, the method-of-moments estimate of between-study variance $\hat{\tau}_r^2$ is defined as the solution to

$$Q_r\sqrt{\frac{\pi}{2}} = \sum_{i=1}^{n}\left\{1 - \frac{w_i}{\sum_{j=1}^{n} w_j} + \tau^2\left[w_i - \frac{2w_i^2}{\sum_{j=1}^{n} w_j} + \frac{w_i\sum_{j=1}^{n} w_j^2}{(\sum_{j=1}^{n} w_j)^2}\right]\right\}.$$

If no positive solution exists to the equation above, set $\hat{\tau}_r^2 = 0$. The counterparts of the H and I^2 statistics are defined as

$$H_r = Q_r\sqrt{\pi/[2n(n-1)]};$$

$$I_r^2 = \frac{Q_r^2 - 2n(n-1)/\pi}{Q_r^2}.$$

To further improve the robustness of heterogeneity assessment, the weighted *mean* in the Q_r statistic may be replaced by the weighted *median* $\hat{\mu}_m$, which is the solution to $\sum_{i=1}^{n} w_i[I(\theta \geq y_i) - 0.5] = 0$ with respect to θ. The new test statistic is

$$Q_m = \sum_{i=1}^{n} \sqrt{w_i}|y_i - \hat{\mu}_m|.$$

Based on Q_m, the new estimator of between-study variance $\hat{\tau}_m^2$ is the solution to

$$Q_m\sqrt{\pi/2} = \sum_{i=1}^{n}\sqrt{(s_i^2 + \tau^2)/s_i^2}.$$

The counterparts of the H and I^2 statistics are

$$H_m = \frac{Q_m}{n}\sqrt{\pi/2};$$

$$I_m^2 = \frac{Q_m^2 - 2n^2/\pi}{Q_m^2}.$$

Value

This function returns a list containing p-values of various heterogeneity tests and various heterogeneity measures with 95% confidence intervals.

References

DerSimonian R and Laird N (1986). "Meta-analysis in clinical trials." *Controlled Clinical Trials*, **7**(3), 177–188.

Higgins JPT and Thompson SG (2002). "Quantifying heterogeneity in a meta-analysis." *Statistics in Medicine*, **21**(11), 1539–1558.

Higgins JPT, Thompson SG, Deeks JJ, and Altman DG (2003). "Measuring inconsistency in meta-analyses." *BMJ*, **327**(7414), 557–560.

Lin L, Chu H, and Hodges JS (2016+). "Alternative measures of between-study heterogeneity in meta-analysis: reducing the impact of outlying studies." *Biometrics*.

Examples

```
data("aex")
set.seed(1234)
attach(aex)
metahet(y, s2, 100)
#metahet(y, s2, 1000)
detach(aex)

data("hipfrac")
set.seed(1234)
attach(hipfrac)
metahet(y, s2, 100)
#metahet(y, s2, 1000)
detach(hipfrac)
```

---

metaoutliers *Outlier Detection in Meta-Analysis*

Description

Calculates the standardized residual for each study in meta-analysis using the methods desribed in Hedges and Olkin (1985) Chapter 12 and Viechtbauer and Cheung (2010). A study is considered as an outlier if its standardized residual is greater than 3 in absolute magnitude.

Usage

```
metaoutliers(y, s2, model)
```

Arguments

`y`	a numeric vector indicating the observed effect sizes in the collected studies; they are assumed to be normally distributed.
`s2`	a numeric vector indicating the within-study variances.

`model` a character string specified as either "FE" or "RE". If model = "FE", this function uses the outlier detection procedure for fixed-effect meta-analysis desribed in Hedges and Olkin (1985) Chapter 12; If model = "RE", the procedure for random-effects meta-analysis desribed in Viechtbauer and Cheung (2010) is used. See Details for the two approaches. If the argument model is not specified, this function sets model = "FE" if $I_r^2 < 30\%$ and sets model = "RE" if $I_r^2 \geq 30\%$.

Details

Suppose that a meta-analysis collects n studies. The observed effect size in study i is y_i and its within-study variance is s_i^2. Also, the inverse-variance weight is $w_i = 1/s_i^2$.

Hedges and Olkin (1985) Chapter 12 describes the outlier detection procedure for fixed-effect meta-analysis (model = "FE"). Using the studies except study i, the pooled estimate of overall effect size is $\bar{\mu}_{(-i)} = \sum_{j \neq i} w_j y_j / \sum_{j \neq i} w_j$. The residual of study i is $e_i = y_i - \bar{\mu}_{(-i)}$. The variance of e_i is $v_i = s_i^2 + (\sum_{j \neq i} w_j)^{-1}$, so the standardized residual of study i is $\epsilon_i = e_i/\sqrt{v_i}$.

Viechtbauer and Cheung (2010) describes the outlier detection procedure for random-effects meta-analysis (model = "RE"). Using the studies except study i, let the method-of-moments estimate of between-study variance be $\hat{\tau}^2_{(-i)}$. The pooled estimate of overall effect size is $\bar{\mu}_{(-i)} = \sum_{j \neq i} \tilde{w}_{(-i)j} y_j / \sum_{j \neq i} \tilde{w}_{(-i)j}$, where $\tilde{w}_{(-i)j} = 1/(s_j^2 + \hat{\tau}^2_{(-i)})$. The residual of study i is $e_i = y_i - \bar{\mu}_{(-i)}$, and its variance is $v_i = s_i^2 + \hat{\tau}^2_{(-i)} + (\sum_{j \neq i} \tilde{w}_{(-i)j})^{-1}$. Then, the standardized residual of study i is $\epsilon_i = e_i/\sqrt{v_i}$.

Value

This functions returns a list which contains standardized residuals and identified outliers. A study is considered as an outlier if its standardized residual is greater than 3 in absolute magnitude.

References

Hedges LV and Olkin I (1985). *Statistical Method for Meta-Analysis*. Academic Press, Orlando, FL.

Viechtbauer W and Cheung MWL (2010). "Outlier and influence diagnostics for meta-analaysis." *Research Synthesis Methods*, **1**(2), 112–125.

Examples

```
data("aex")
attach(aex)
metaoutliers(y, s2, model = "FE")
metaoutliers(y, s2, model = "RE")
detach(aex)

data("hipfrac")
attach(hipfrac)
metaoutliers(y, s2)
detach(hipfrac)
```

plot.metaoutliers — *Standardized Residual Plot for Outliers Diagnostics*

Description

Draws a plot showing study-specific standardized residuals.

Usage

```
## S3 method for class 'metaoutliers'
plot(x, xtick.cex = 1, ytick.cex = 0.5, ...)
```

Arguments

`x`	an object created by the function `metaoutliers()`.
`xtick.cex`	a numerical value indicating the magnification to be used for ticks on x-axis.
`ytick.cex`	a numerical value indicating the magnification to be used for ticks on y-axis.
`...`	Other arguments can be passed to `plot()` function.

See Also

`metaoutliers`

Examples

```
data("aex")
attach(aex)
out.aex <- metaoutliers(y, s2, model = "FE")
detach(aex)
plot(out.aex)

data("hipfrac")
attach(hipfrac)
out.hipfrac <- metaoutliers(y, s2, model = "RE")
detach(hipfrac)
plot(out.hipfrac)
```

slf — *A Meta-Analysis for Investigating the Effect of Nicotine Gum for Smoking Cessation*

Description

This meta-analysis serves as an example to illustrate the function usage in the package **altmeta**.

Usage

```
data("slf")
```

Format

A data frame containing 56 studies with the observed effect sizes and their within-study variances.

`y` The observed effect size for each collected study in the meta-analysis.

`s2` The within-study variance for each study.

Source

Stead LF, Perera R, Bullen C, Mant D, Hartmann-Boyce J, Cahill K, and Lancaster T (2012). "Nicotine replacement therapy for smoking cessation." *Cochrane Database of Systematic Reviews*, **11**. Art No.: CD000146. DOI: 10.1002/14651858.CD000146.pub4.

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