

Package: dunn.test (via r-universe)

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Title Dunn's Test of Multiple Comparisons Using Rank Sums

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Description Computes Dunn's test (1964) for stochastic dominance and reports the results among multiple pairwise comparisons after a Kruskal-Wallis test for 0th-order stochastic dominance among k groups (Kruskal and Wallis, 1952). 'dunn.test' makes $k(k-1)/2$ multiple pairwise comparisons based on Dunn's z-test-statistic approximations to the actual rank statistics. The null hypothesis for each pairwise comparison is that the probability of observing a randomly selected value from the first group that is larger than a randomly selected value from the second group equals one half; this null hypothesis corresponds to that of the Wilcoxon-Mann-Whitney rank-sum test. Like the rank-sum test, if the data can be assumed to be continuous, and the distributions are assumed identical except for a difference in location, Dunn's test may be understood as a test for median difference and for mean difference. 'dunn.test' accounts for tied ranks.

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| | |
|-----------|--------------------|
| dunn.test | <i>Dunn's Test</i> |
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Description

Performs Dunn's test of multiple comparisons using rank sums

Usage

```
dunn.test (x, g=NA, method=p.adjustment.methods, kw=TRUE, label=TRUE,
          wrap=FALSE, table=TRUE, list=FALSE, rmc=FALSE, alpha=0.05, altp=FALSE)
```

```
p.adjustment.methods
```

```
# c("none", "bonferroni", "sidak", "holm", "hs", "hochberg", "bh", "by")
```

Arguments

| | |
|--------|---|
| x | a numeric vector, or a list of numeric vectors. Missing values are ignored. If the former, then groups <i>must</i> be specified using g. |
| g | a factor variable, numeric vector, or character vector indicating group. Missing values are ignored. |
| method | adjusts the <i>p</i> -value for multiple comparisons using the Bonferroni, Šidák, Holm, Holm-Šidák, Hochberg, Benjamini-Hochberg, or Benjamini-Yekutieli adjustment (see Details). The default is no adjustment for multiple comparisons. |
| kw | if 'TRUE' then the results of the Kruskal-Wallis test are reported. |
| label | if 'TRUE' then the factor labels are used in the output table. |
| wrap | does not break up tables to maintain nicely formatted output. If 'FALSE' then output of large tables is broken up across multiple pages. |
| table | outputs results of Dunn's test in a table format, as qualified by the label and wrap options. |
| list | outputs results of Dunn's test in a list format. |
| rmc | if 'TRUE' then the reported test statistics and table are based on row minus column, rather than the default column minus row (i.e. the signs of the test statistic are flipped). |
| alpha | the nominal level of significance used in the step-up/step-down multiple comparisons procedures (Holm, Holm-Šidák, Hochberg, Benjamini-Hochberg, and Benjamini-Yekutieli). |

altp if 'TRUE' then express p -values in alternative format. The default is to express p -value = $P(Z \geq |z|)$, and reject H_0 if $p \leq \alpha/2$. When the altp option is used, p -values are instead expressed as p -value = $P(|Z| \geq |z|)$, and reject H_0 if $p \leq \alpha$. **These two expressions give identical test results.** Use of altp is therefore merely a semantic choice.

Details

dunn.test computes Dunn's test (1964) for stochastic dominance and reports the results among multiple pairwise comparisons after a Kruskal-Wallis test for stochastic dominance among k groups (Kruskal and Wallis, 1952). The interpretation of stochastic dominance requires an assumption that the CDF of one group does not cross the CDF of the other. dunn.test makes $m = k(k-1)/2$ multiple pairwise comparisons based on Dunn's z -test-statistic approximations to the actual rank statistics. The null hypothesis for each pairwise comparison is that the probability of observing a randomly selected value from the first group that is larger than a randomly selected value from the second group equals one half; this null hypothesis corresponds to that of the Wilcoxon-Mann-Whitney rank-sum test. Like the rank-sum test, if the data can be assumed to be continuous, and the distributions are assumed identical except for a difference in location, Dunn's test may be understood as a test for median difference. dunn.test accounts for tied ranks.

dunn.test outputs both z -test-statistics for each pairwise comparison and the p -value = $P(Z \geq |z|)$ for each. Reject H_0 based on $p \leq \alpha/2$ (and in combination with p -value ordering for stepwise method options). If you prefer to work with p -values expressed as p -value = $P(|Z| \geq |z|)$ use the altp=TRUE option, and reject H_0 based on $p \leq \alpha$ (and in combination with p -value ordering for stepwise method options). These are exactly equivalent rejection decisions.

Several options are available to adjust p -values for multiple comparisons, including methods to control the family-wise error rate (FWER) and methods to control the false discovery rate (FDR):

- 'none' no adjustment is made. Those comparisons rejected without adjustment at the α level (two-sided test) are starred in the output table, and starred in the list when using the list=TRUE option.
- 'bonferroni' the FWER is controlled using Dunn's (1961) Bonferroni adjustment, and adjusted p -values = $\max(1, pm)$. Those comparisons rejected with the Bonferroni adjustment at the α level (two-sided test) are starred in the output table, and starred in the list when using the list=TRUE option.
- 'sidak' the FWER is controlled using Šidák's (1967) adjustment, and adjusted p -values = $\max(1, 1 - (1 - p)^m)$. Those comparisons rejected with the Šidák adjustment at the α level (two-sided test) are starred in the output table, and starred in the list when using the list=TRUE option.
- 'holm' the FWER controlled using Holm's (1979) progressive step-up procedure to relax control on subsequent tests. p values are ordered from smallest to largest, and adjusted p -values = $\max[1, p(m+1-i)]$, where i indexes the ordering. All tests after and including the first test to not be rejected are also not rejected.
- 'hs' the FWER is controlled using the Holm-Šidák adjustment (Holm, 1979): another progressive step-up procedure but assuming dependence between tests. p values

are ordered from smallest to largest, and adjusted p -values = $\max[1, 1 - (1 - p)^{(m+1-i)}]$, where i indexes the ordering. All tests after and including the first test to not be rejected are also not rejected.

- 'hochberg' the FWER is controlled using Hochberg's (1988) progressive step-down procedure to increase control on successive tests. p values are ordered from largest–smallest, and adjusted p -values = $\max[1, p^*i]$, where i indexes the ordering. All tests after and including the first to be rejected are also rejected.
- 'bh' the FDR is controlled using the Benjamini-Hochberg adjustment (1995), a step-down procedure appropriate to independent tests or tests that are positively dependent. p -values are ordered from largest to smallest, and adjusted p -values = $\max[1, pm/(m+1-i)]$, where i indexes the ordering. All tests after and including the first to be rejected are also rejected.
- 'by' the FDR is controlled using the Benjamini-Yekutieli adjustment (2011), a step-down procedure appropriate to dependent tests. p -values are ordered from largest to smallest, and adjusted p -values = $\max[1, pmC/(m+1-i)]$, where i indexes the ordering, and the constant $C = 1 + 1/2 + \dots + 1/m$. All tests after and including the first to be rejected are also rejected.

Because the sequential step-up/step-down tests rejection decisions depend on both the p -values and their ordering, those tests rejected using "holm", "hs", "hochberg", "bh", or "by" at the indicated α level are starred in the output table, and starred in the list when using the `list=TRUE` option.

Value

dunn.test returns:

| | |
|-------------|---|
| chi2 | a scalar of the Kruskal-Wallis test statistic adjusted for ties. |
| Z | a vector of all m of Dunn z test statistics. |
| P | a vector of p -values corresponding to Z. –OR– |
| altP | a vector of p -values corresponding to Z when using the <code>altP=TRUE</code> option. |
| P.adjust | a vector of p -values corresponding to Z, but adjusted for multiple comparisons as per method (P = P.adjust if method="none"). –OR– |
| altP.adjust | a vector of p -values corresponding to Z, but adjusted for multiple comparisons as per method (P = P.adjust if method="none") when using the <code>altP=TRUE</code> option. |
| comparisons | a vector of strings labeling each pairwise comparison, as qualified by the <code>rmc</code> option, using either the variable values, or the factor labels or (or factor values if unlabeled). These labels match the corresponding position in the Z, P, and P.adjust vectors. |

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Please contact me with any questions, bug reports or suggestions for improvement. Fixing bugs will be facilitated by sending along:

- [1] a copy of the data (de-labeled or anonymized is fine),
- [2] a copy of the command syntax used, and
- [3] a copy of the exact output of the command.

References

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- Kruskal, W. H. and Wallis, A. (1952) Use of ranks in one-criterion variance analysis. *Journal of the American Statistical Association*. **47**, 583–621. <doi:10.1080/01621459.1952.10483441>.
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Examples

```
## Example cribbed and modified from the kruskal.test documentation
## Hollander & Wolfe (1973), 116.
## Mucociliary efficiency from the rate of removal of dust in normal
## subjects, subjects with obstructive airway disease, and subjects
## with asbestosis.
x <- c(2.9, 3.0, 2.5, 2.6, 3.2) # normal subjects
y <- c(3.8, 2.7, 4.0, 2.4)     # with obstructive airway disease
z <- c(2.8, 3.4, 3.7, 2.2, 2.0) # with asbestosis
dunn.test(x=list(x,y,z))

x <- c(x, y, z)
g <- factor(rep(1:3, c(5, 4, 5)),
            labels = c("Normal",
                       "COPD",
                       "Asbestosis"))
dunn.test(x, g)

## Example based on home care data from Dunn (1964)
```

```
data(homecare)
attach(homecare)
dunn.test(occupation, eligibility, method="hs", list=TRUE)

## Air quality data set illustrates differences in different
## multiple comparisons adjustments
attach(airquality)
dunn.test(Ozone, Month, kw=FALSE, method="bonferroni")
dunn.test(Ozone, Month, kw=FALSE, method="hs")
dunn.test(Ozone, Month, kw=FALSE, method="bh")
detach(airquality)
```

homecare

Occupation and Home Care Eligibility

Description

Occupation and home care eligibility for 383 patients medically eligible for home care.

Usage

homecare

Format

A data frame containing two variables, occupation and eligibility, over 383 observations.

Source

Dunn, O. J. (1964) Multiple comparisons using rank sums. *Technometrics*, **6(3)**, 241–252s. Table 1. <[doi:10.1080/00401706.1964.10490181](https://doi.org/10.1080/00401706.1964.10490181)>.

References

The data have been adapted from a study of a group of patients entering the Los Angeles County General Hospital during the years 1959-61.

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