

statsExpressions: R Package for Tidy Dataframes and Expressions with Statistical Details

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Summary

The statsExpressions package has two key aims: to provide a consistent syntax to do statistical analysis with tidy data, and to provide statistical expressions (i.e., pre-formatted in-text statistical results) for plotting functions. Currently, it supports common types of statistical approaches and tests: parametric, nonparametric, robust, and Bayesian *t*-test, one-way ANOVA, correlation analyses, contingency table analyses, and meta-analyses. The functions are pipe-friendly and compatible with tidy data.

Statement of need

Statistical packages exhibit substantial diversity in terms of their syntax and expected input and output data type. For example, some functions expect vectors as inputs, while others expect dataframes. Depending on whether it is a repeated measures design or not, functions from the same package might expect data to be in wide or tidy format. Some functions can internally omit missing values, while others do not. Furthermore, the statistical test objects returned by the test functions might not have all required information (e.g., degrees of freedom, significance, Bayes factor, etc.) accessible in a consistent data type. Depending on the specific test object and statistic in question, details may be returned as a list, a matrix, an array, or a dataframe. This diversity can make it difficult to easily access all needed information for hypothesis testing and estimation, and to switch from one statistical approach to another.

This is where statsExpressions comes in: It can be thought of as a unified portal through which most of the functionality in these underlying packages can be accessed, with a simpler interface and with tidy data format.

Comparison to Other Packages

Unlike broom ([Robinson et al., 2021](#)) or parameters ([Lüdtke et al., 2020](#)), the goal of statsExpressions is not to convert model objects into tidy dataframes, but to provide a consistent and easy syntax to carry out statistical tests. Additionally, none of these packages return statistical expressions.

Consistent Syntax for Statistical Analysis

The package offers functions that allow users choose a statistical approach without changing the syntax (i.e., by only specifying a single argument). The functions always require a

dataframe in tidy format (Wickham et al., 2019), and work with missing data. Moreover, they always return a dataframe that can be further utilized downstream in the workflow (such as visualization).

Table 1: A summary table listing the primary functions in the package and the statistical approaches they support. More detailed description of the tests and outputs from these functions can be found on the package website: <https://indrajeetpatil.github.io/statsExpressions/articles/>.

Function	Parametric	Non-parametric	Robust	Bayesian
one_sample_test	✓	✓	✓	✓
two_sample_test	✓	✓	✓	✓
oneway_anova	✓	✓	✓	✓
corr_test	✓	✓	✓	✓
contingency_table	✓	✓	-	✓
meta_analysis	✓	-	✓	✓

statsExpressions internally relies on stats package for parametric and non-parametric (R Core Team, 2021), WRS2 package for robust (Mair & Wilcox, 2020), and BayesFactor package for Bayesian statistics (Morey & Rouder, 2020). The random-effects meta-analysis is carried out using metafor (parametric) (Viechtbauer, 2010), metaplan (robust) (Beath, 2016), and metaBMA (Bayesian) (Heck et al., 2019) packages. Additionally, it relies on easystats packages (Ben-Shachar et al., 2020; Lüdtke et al., 2019, 2020, 2021; Makowski et al., 2019, 2020) to compute appropriate effect size/posterior estimates and their confidence/credible intervals.

Tidy Dataframes from Statistical Analysis

To illustrate the simplicity of this syntax, let's say we want to run a one-way ANOVA. If we first run a non-parametric ANOVA and then decide to run a robust ANOVA instead, the syntax remains the same and the statistical approach can be modified by changing a single argument:

```
mtcars %>% oneway_anova(cyl, wt, type = "nonparametric")
#> # A tibble: 1 x 14
#>   parameter1 parameter2 statistic df.error p.value
#>   <chr>      <chr>      <dbl>   <int>   <dbl>
#> 1 wt          cyl          22.8     2 0.0000112
#>   method                estimate conf.level conf.low conf.high
#>   <chr>                  <dbl>   <dbl>   <dbl>   <dbl>
#> 1 Kruskal-Wallis rank sum test  0.736    0.95   0.613   0.831
#>   effectsize    conf.method conf.iterations expression
#>   <chr>         <chr>              <int> <list>
#> 1 Epsilon2 (rank) bootstrap          100 <language>

mtcars %>% oneway_anova(cyl, wt, type = "robust")
#> # A tibble: 1 x 11
#>   statistic df df.error p.value estimate conf.level conf.low conf.high
#>   <dbl> <dbl> <dbl>   <dbl>   <dbl>   <dbl>   <dbl>   <dbl>
#> 1 12.7    2 12.2 0.00102 1.05    0.95   0.843   1.50
#>   effectsize
#>   <chr>
#> 1 Explanatory measure of effect size
```

```
#> method expression
#> <chr> <list>
#> 1 A heteroscedastic one-way ANOVA for trimmed means <language>
```

These functions are also compatible with other popular data manipulation packages (see Appendix for an example).

Expressions for Plots

In addition to other details contained in the dataframe, there is also a column titled `expression`, which contains a pre-formatted text with statistical details. These expressions (Figure 1) attempt to follow the gold standard in statistical reporting for both Bayesian (Doorn et al., 2020) and Frequentist (American Psychological Association and others, 2019) frameworks.

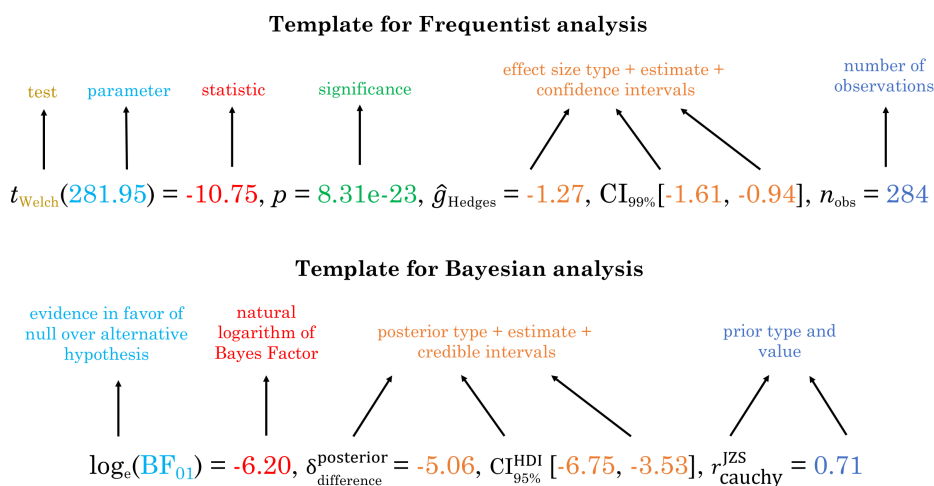


Figure 1: The templates used in ‘statsExpressions’ to display statistical details in a plot.

This expression be easily displayed in a plot (Figure 2). Displaying statistical results in the context of a visualization is indeed a philosophy adopted by the `ggstatsplot` package (Patil, 2021), and `statsExpressions` functions as its statistical processing backend.

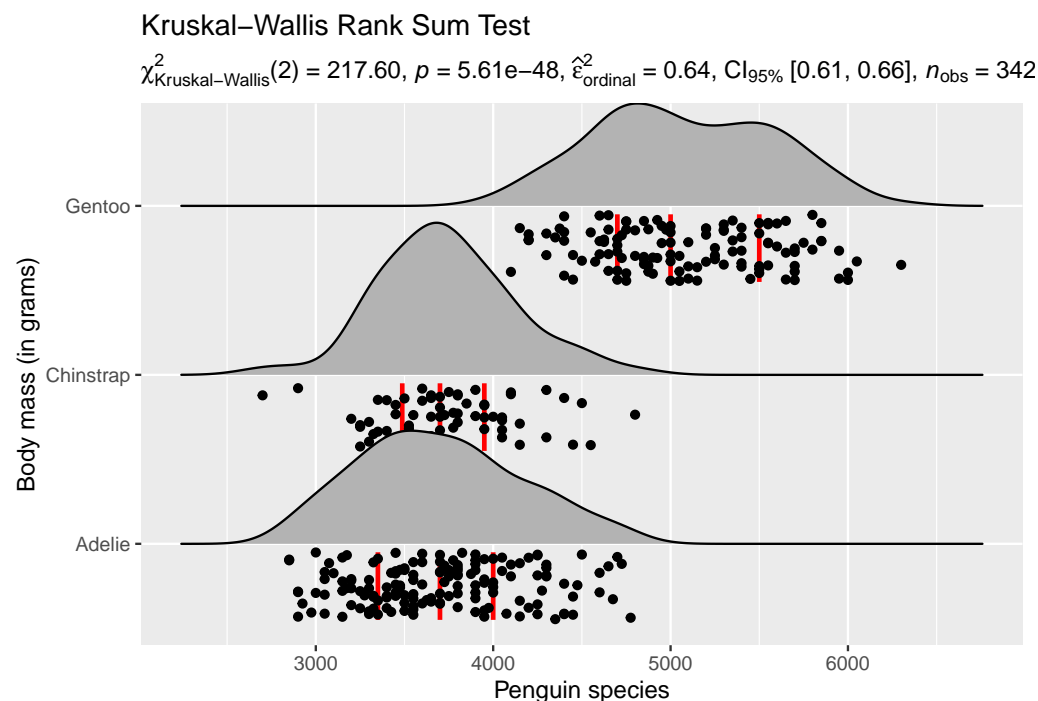


Figure 2: Example illustrating how ‘statsExpressions’ functions can be used to display results from a statistical test in a plot. Code to create this figure is reported in Appendix.

Licensing and Availability

statsExpressions is licensed under the GNU General Public License (v3.0), with all source code stored at [GitHub](#). In the spirit of honest and open science, requests and suggestions for fixes, feature updates, as well as general questions and concerns are encouraged via direct interaction with contributors and developers by filing an [issue](#) while respecting [Contribution Guidelines](#).

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Appendix

Example with dplyr

We can use combination of dplyr and statsExpressions to repeat the same statistical analysis across grouping variables.

```
# running one-sample proportion test for all levels of `cyl`
mtcars %>%
  group_by(cyl) %>%
  group_modify(~ contingency_table(.x, am), .keep = TRUE) %>%
  ungroup()
#> # A tibble: 3 x 13
#>   cyl statistic    df p.value method
#>   <dbl>      <dbl> <dbl>   <dbl> <chr>
#> 1     4        2.27     1 0.132 Chi-squared test for given probabilities
#> 2     6        0.143    1 0.705 Chi-squared test for given probabilities
#> 3     8        7.14     1 0.00753 Chi-squared test for given probabilities
#>   estimate conf.level conf.low conf.high effectsize      conf.method
#>   <dbl>      <dbl>   <dbl>   <dbl> <chr>          <chr>
#> 1  0.344      0.95     0        0.917 Cramer's V (adj.) ncp
#> 2  0          0.95     0          0 Cramer's V (adj.) ncp
#> 3  0.685      0.95    0.127    1.18 Cramer's V (adj.) ncp
#>   conf.distribution expression
#>   <chr>                  <list>
#> 1 chisq                  <language>
#> 2 chisq                  <language>
#> 3 chisq                  <language>
```

Code to reproduce for Figure 2

```
# needed libraries
library(statsExpressions)
library(ggplot2)
library(ggrridges)
library(palmerpenguins) # `penguins` dataset is from this package

# creating a dataframe
res <- oneway_anova(penguins, species, body_mass_g, type = "nonparametric")

# create a ridgeplot using `ggrridges` package
ggplot(penguins, aes(x = body_mass_g, y = species)) +
  geom_density_ridges(
    jittered_points = TRUE,
    quantile_lines = TRUE,
    scale = 0.9,
    vline_size = 1,
    vline_color = "red",
    position = position_raincloud(adjust_vlines = TRUE)
  ) + # use 'expression' column to display results in the subtitle
  labs(
```

```
x = "Penguin species",  
y = "Body mass (in grams)",  
title = "Kruskal-Wallis Rank Sum Test",  
subtitle = res$expression[[1]]  
)
```