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see: An R Package for Visualizing Statistical Models

Daniel Lüdecke[1], **Indrajeet Patil**[2], **Mattan S. Ben-Shachar**[3], **Brenton M. Wiernik**[4], **Philip Waggoner**[5], **and Dominique Makowski**[6]

1 University Medical Center Hamburg-Eppendorf, Germany **2** Center for Humans and Machines, Max Planck Institute for Human Development, Berlin, Germany **3** Ben-Gurion University of the Negev, Israel **4** Department of Psychology, University of South Florida, USA **5** University of Chicago, USA **6** Nanyang Technological University, Singapore

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Summary

The *see* package is embedded in the *easystats* ecosystem, a collection of R packages that operate in synergy to provide a consistent and intuitive syntax when working with statistical models in the R programming language (R Core Team, 2021). Most *easystats* packages return comprehensive numeric summaries of model parameters and performance. The *see* package complements these numeric summaries with a host of functions and tools to produce a range of publication-ready visualizations for model parameters, predictions, and performance diagnostics. As a core pillar of *easystats*, the *see* package helps users to utilize visualization for more informative, communicable, and well-rounded scientific reporting.

Statement of Need

The grammar of graphics (Wilkinson, 2012), largely due to its implementation in the *ggplot2* package (Wickham, 2016), has become the dominant approach to visualization in R. Building a model visualization with *ggplot2* is somewhat disconnected from the model fitting and evaluation process. Generally, this process entails:

1. Fitting a model.
2. Extracting desired results from the model (e.g., model parameters and intervals, model predictions, diagnostic statistics) and arranging them into a dataframe.
3. Passing the results dataframe to `ggplot()` and specifying the graphical parameters. For example:

```
library(ggplot2)

# step-1
model <- lm(mpg ~ factor(cyl) * wt, data = mtcars)

# step-2
results <- fortify(model)

# step-3
ggplot(results) +
  geom_point(aes(x = wt, y = mpg, color = factor(cyl))) +
  geom_line(aes(x = wt, y = .fitted, color = `factor(cyl)`))
```

A number of packages have been developed to extend *ggplot2* and assist with model visualization.[1] Some of these packages provide functions for additional geoms, annotations, or common visualization types without linking them to a specific statistical analysis or fundamentally changing the *ggplot2* workflow (e.g., *ggrepel*, *ggalluvial*, *ggridges*, *ggdist*, *ggpubr*, etc.). Other *ggplot2* extensions provide functions to generate publication-ready visualizations for specific types of models (e.g., *metaviz*, *tidymv*, *sjPlot*, *survminer*). For example, the *ggstatsplot* package (Patil, 2021) offers visualizations for statistical analysis of one-way factorial designs, the *plotmm* package (Waggoner, 2020) supports specific types of mixture model objects. The `fortify` function from *ggfortify* package (Horikoshi & Tang, 2018) *does* offer a unified plotting framework for a wide range of statistical models, although it is not as comprehensive as the *see* package because the *easystats* ecosystem covers a much larger collection of statistical models.

The aim of the *see* package is to produce visualizations for a wide variety of models and statistical analyses in a way that is tightly linked with the model fitting process and requires minimal interruption of users' workflow. *see* accomplishes this aim by providing a single `plot()` method for objects created by the other *easystats* packages, such as *parameters* tables, *modelbased* predictions, *performance* diagnostic tests, *correlation* matrices, and so on. The *easystats* packages compute numeric results for a wide range of statistical models, and the *see* package acts as a visual support to the entire *easystats* ecosystem. As such, visualizations corresponding to all stages of statistical analysis, from model fitting to diagnostics to reporting, can be easily created using *see*. *see* plots are compatible with other *ggplot2* functions for further customization (e.g., `labs()` for a plot title). In addition, *see* provides several aesthetic utilities to embellish both *easystats* plots and other *ggplot2* plots. The result is a package that minimizes the barrier to producing high-quality statistical visualizations in R.

The central goal of *easystats* is to make the task of doing statistics in R as easy as possible. This goal is realized through intuitive and consistent syntax, consistent and transparent argument names, comprehensive documentation, informative warnings and error messages, and smart functions with sensible default parameter values. The *see* package follows this philosophy by using a single access point—the generic `plot()` method—for visualization of all manner of statistical results supported by *easystats*.

Features

Below we present one or two plotting methods for each *easystats* package, but many other methods are available. Interested readers are encouraged to explore the range of examples on the package website, https://easystats.github.io/see/.

Themes and Palettes

The package includes different **ggplot2** themes that one can set for each plot, or generally as shown below:

```
ggplot2::theme_set(see::theme_modern())
```

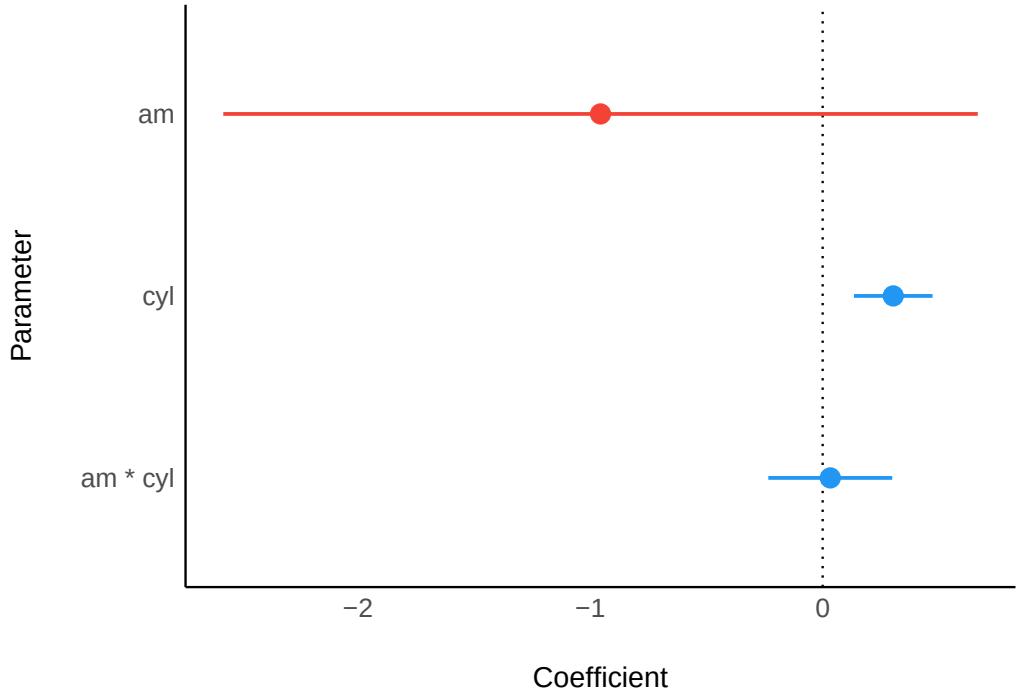
The package provides also color palettes, such as `scale_color_material` or `scale_color_flat` for material and flat design colors (https://www.materialui.co/colors), respectively.

[1] For a sampling of these packages, visit https://exts.ggplot2.tidyverse.org/gallery/

Visualizing Model Parameters

The *parameters* package converts summaries of regression model objects into dataframes (Lüdecke et al., 2020). The *see* package can take this transformed object and, for example, create a dot-and-whisker plot for the extracted regression estimates simply by passing the `parameters` class object to `plot()`.

```
library(parameters)
library(see)
library(ggplot2)

model <- lm(wt ~ am * cyl, data = mtcars)

plot(parameters(model))
```

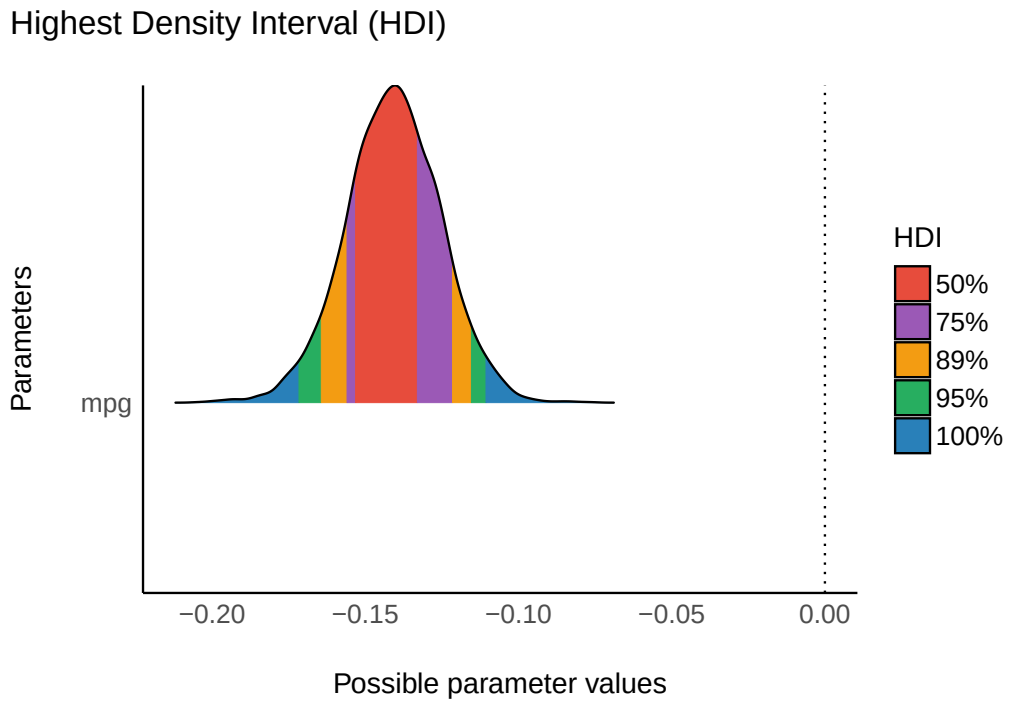


As *see* outputs objects of class `ggplot`, *ggplot2* functions can be added as layers to the plot the same as with all other *ggplot2* visualizations. For example, we might add a title using `labs()` from *ggplot2*.

```
library(parameters)
library(see)

model <- lm(wt ~ am * cyl, data = mtcars)

# changing title and axis labels using ggplot2 functions
plot(parameters(model)) +
  labs(title = "A Dot-and-Whisker Plot") +
  scale_x_discrete(labels = c(
    "transmission * cylinders",
    "cylinders",
    "transmission"
  ))
```

Similarly, for Bayesian regression model objects, which are handled by the *bayestestR* package (Makowski et al., 2019), the *see* package provides special plotting methods relevant for Bayesian models (e.g., Highest Density Interval, or *HDI*). Users can fit the model and pass the model results, extracted via *bayestestR*, to `plot()`.

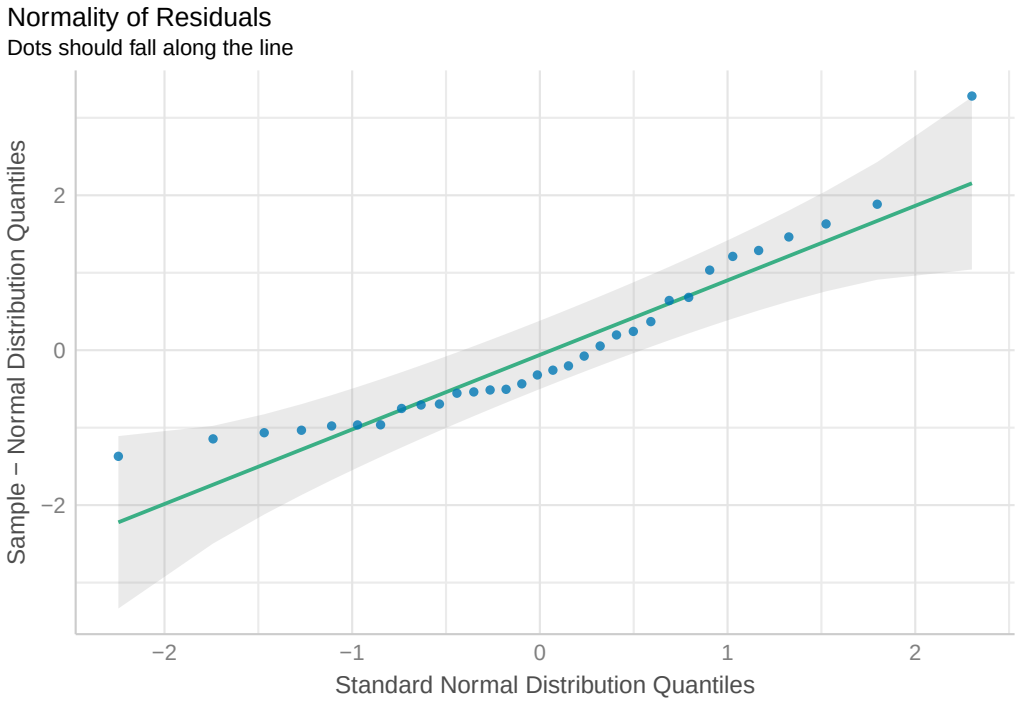
```
library(bayestestR)
library(rstanarm)
library(see)

model <- stan_glm(wt ~ mpg, data = mtcars, refresh = 0)
result <- hdi(model, ci = c(0.5, 0.75, 0.89, 0.95))

plot(result)
```



Visualizing Model Performance and Diagnostic Checks

The *performance* package is primarily concerned with checking regression model assumptions (Lüdecke et al., 2021). The *see* package offers tools to visualize these assumption checks, such as the normality of residuals. Users simply pass the fit model object to the relevant *performance* function (`check_normality()` in the example below). Then, this result can be passed to `plot()` to produce a *ggplot2* visualization of the check on normality of the residuals.

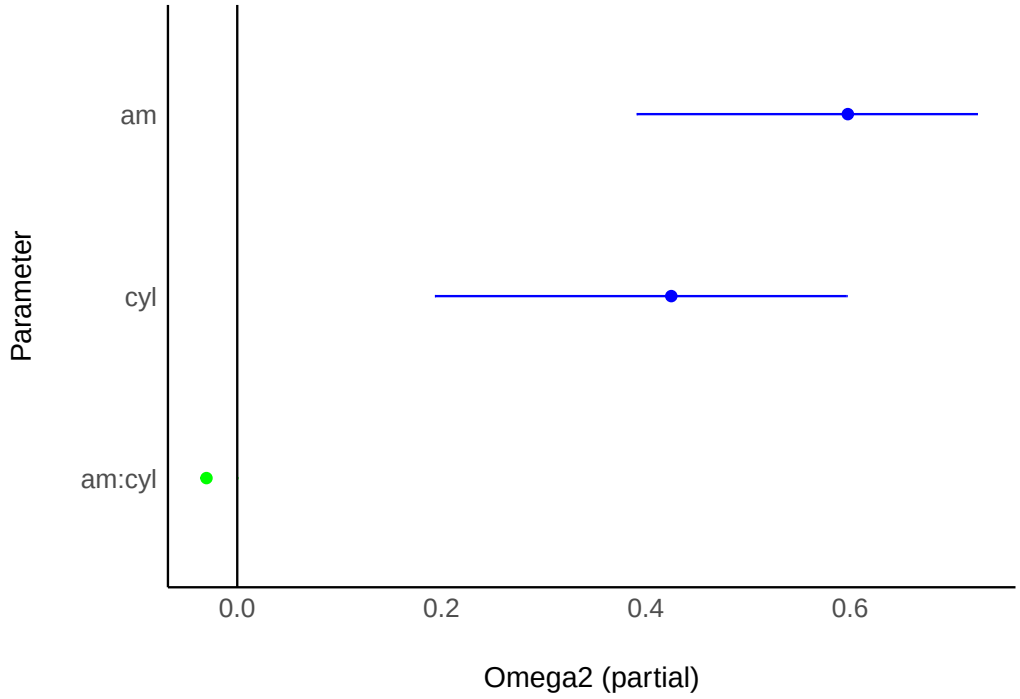
```
library(performance)
library(see)

model <- lm(wt ~ mpg, data = mtcars)
check <- check_normality(model)
#> Warning: Non-normality of residuals detected (p = 0.016).

plot(check, type = "qq")
```



Visualizing Effect Sizes

The *effectsize* package computes a variety of effect size metrics for fitted models to assesses the practical importance of observed effects (Ben-Shachar et al., 2020). In conjunction with *see*, users are able to visualize the magnitude and uncertainty of effect sizes by passing the model object to the relevant *effectsize* function (`omega_squared()` in the following example), and then to `plot()`.

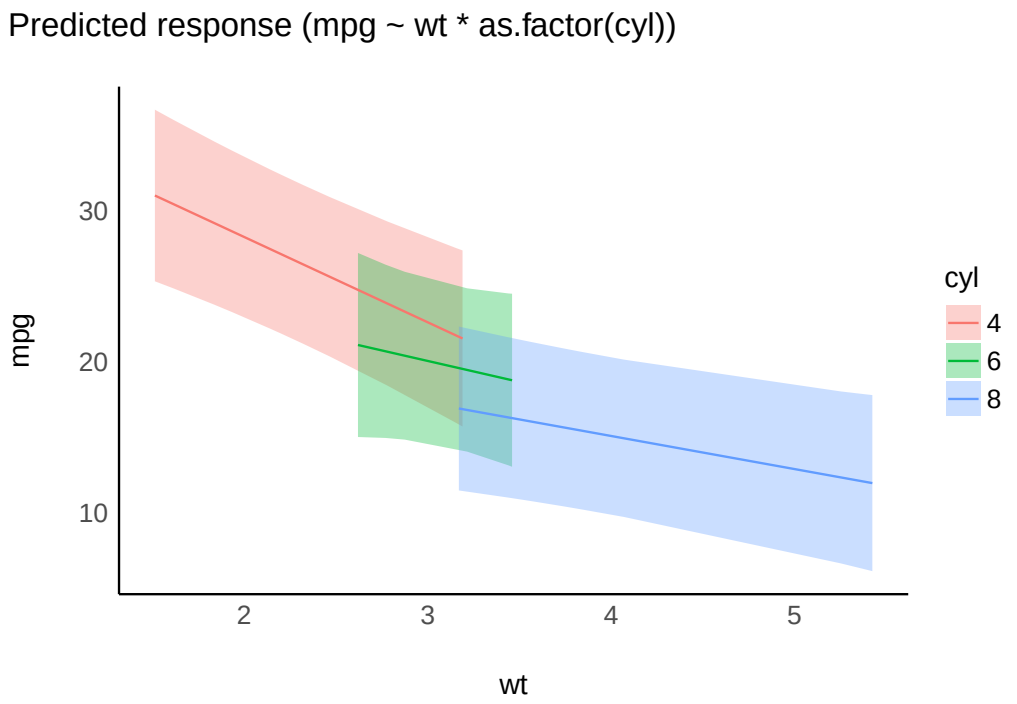
```
library(effectsize)
library(see)

model <- aov(wt ~ am * cyl, data = mtcars)

plot(omega_squared(model))
```



Visualizing Model Predictions and Marginal Effects

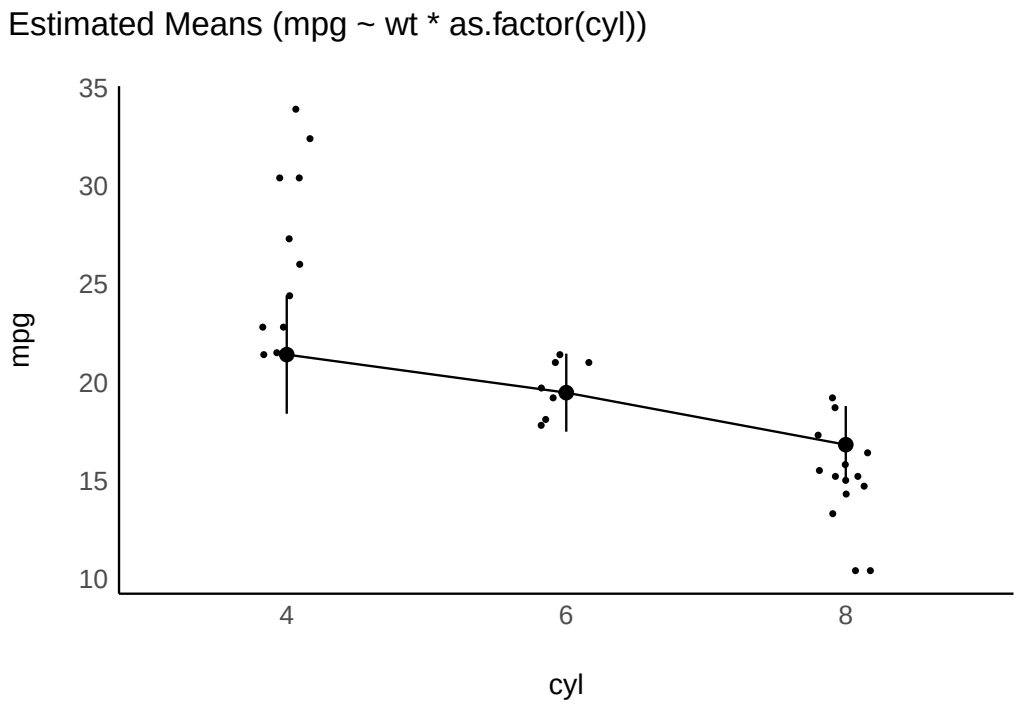
The *modelbased* package computes model-based estimates and predictions from fitted models (Makowski et al., 2020a). *see* provides methods to quickly visualize these model predictions.

```
library(modelbased)
library(see)

model <- lm(mpg ~ wt * as.factor(cyl), data = mtcars)
predicted <- estimate_prediction(model)

plot(predicted)
```



One can also visualize *marginal means* (i.e., the mean at each factor level averaged over other predictors) using `estimate_means()`, that is then passed to `plot()`.

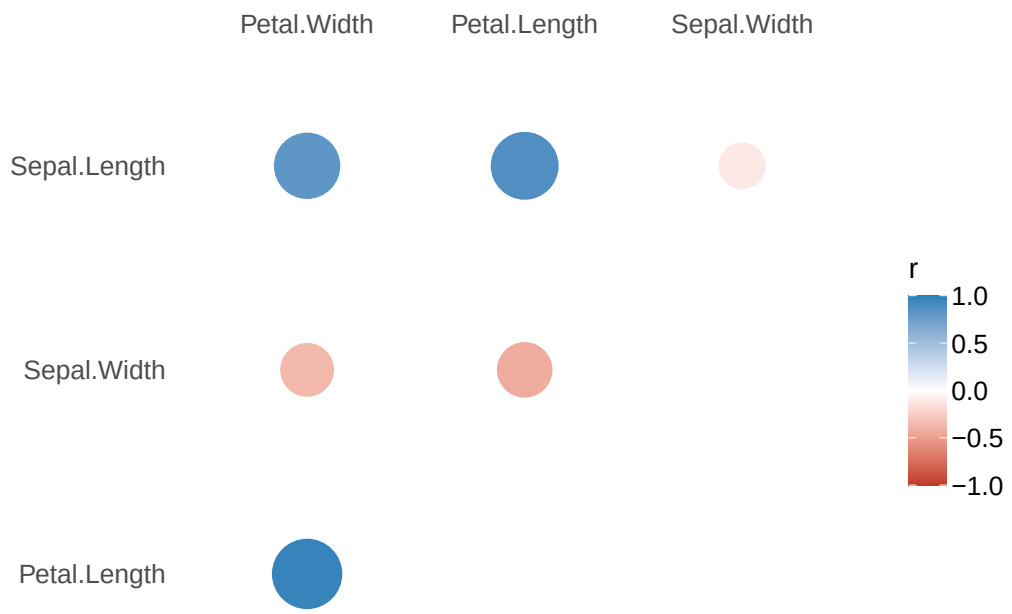
```
means <- estimate_means(model)

plot(means)
```



Visualizing Correlation Matrices

The *correlation* package provides a unified syntax and human-readable code to carry out many types of correlation analysis (Makowski et al., 2020b). A user can run `summary(correlation(data))` to create a construct a correlation matrix for the variables in a dataframe. With *see*, this matrix can be passed to `plot()` to visualize these correlations in a correlation matrix.

```
library(correlation)
library(see)

results <- summary(correlation(iris))

plot(results)
```



Licensing and Availability

see is licensed under the GNU General Public License (v3.0), with all source code openly developed and stored at GitHub (https://github.com/easystats/see), along with a corresponding issue tracker for bug reporting and feature enhancements. In the spirit of honest and open science, we encourage requests, tips for fixes, feature updates, as well as general questions and concerns via direct interaction with contributors and developers.

Acknowledgments

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