

Building R Packages

source at https://github.com/muschellij2/smi_2019

John Muschelli, slides at http://johnmuschelli.com/ENAR_2020.html

What are R Packages?

R Packages

1. Sets of Functions
2. Set of Functions + Documentation
3. Set of Functions + Documentation + Data
4. Set of Functions + Documentation + Data + Vignettes
5. Set of Functions + Documentation + Data + Vignettes + Versions
6. Set of Functions + Documentation + Data + Vignettes + Versions + Dependencies

The resource with All the information

<https://cran.r-project.org/doc/manuals/r-release/R-exts.html>

Writing R Extensions

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What's in a Name?

Package Names:

- must start with letter
- no underscores
- periods allowable or use CamelCase
- can have numbers
- should be Google-able

What's in a Name?

Use `available` pkg to see if name taken:

```
install.packages("available")
```

```
available::available("enar", browse = FALSE) # if want "enar"
```

— enar —

Name valid: ✓

Available on CRAN: ✗

Available on Bioconductor: ✓

Available on GitHub: ✗

Abbreviations: <http://www.abbreviations.com/enar>

Wikipedia: <https://en.wikipedia.org/wiki/enar>

Wiktionary: <https://en.wiktionary.org/wiki/enar>

Urban Dictionary:

Not found.

Sentiment:???

Starting Up

- This will use [GitHub](#) for packages, sign up for an account if you don't have one.

We'll be using `devtools`, `usethis`, and others, install:

```
install.packages(c("devtools", "usethis"))
```

In RStudio, File → New Project → New Directory → R Package using devtools (scroll down). Let's call it `enar2020`.

Trying our first build

In RStudio, click `Build` → `Clean and Rebuild`.

Boom! You have a package installed.

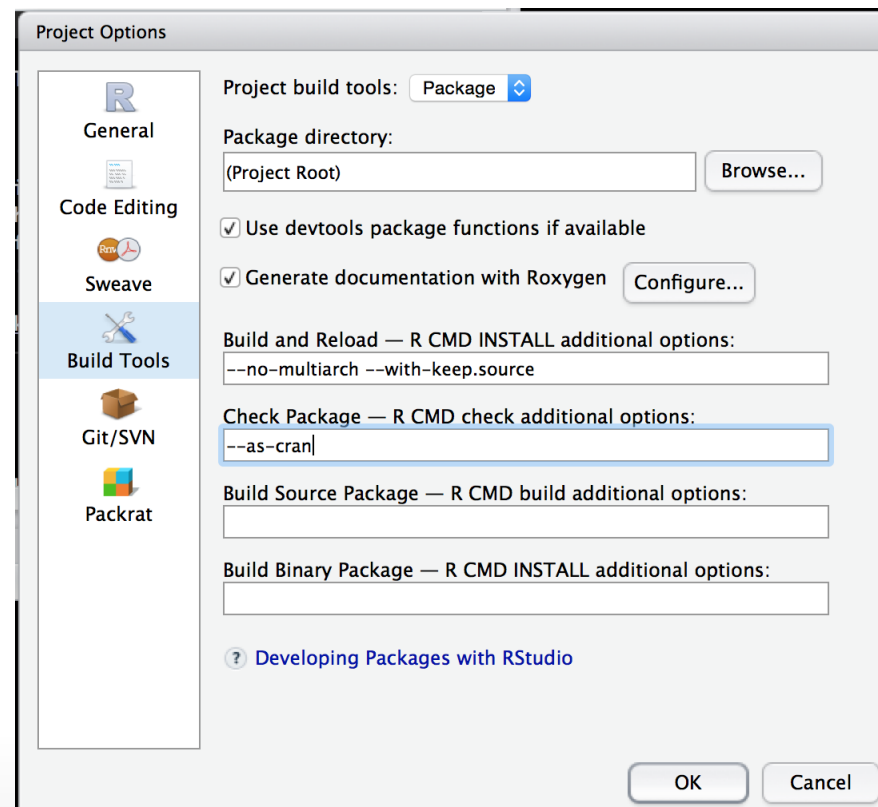
In RStudio, click `Build` → `Check Package`.

This checks our package.

Setting Up RStudio

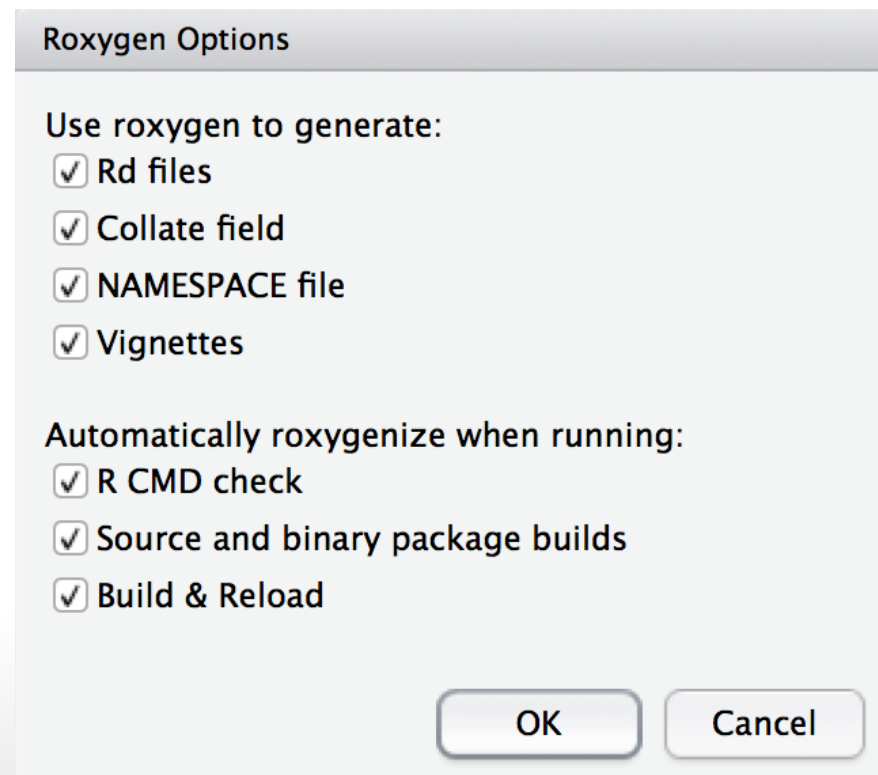
Go to Build -> Configure Build Tools

Can add options to “Check Package” (like `--as-cran`)

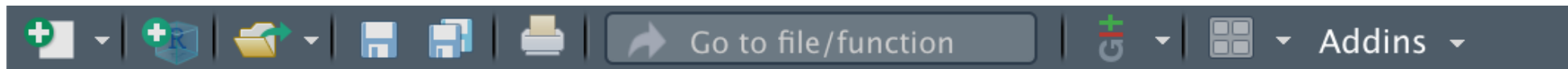


Setting Up: Documentation

In RStudio, click Build → Configure Build Tools → Generate Documentation with Roxygen. If that is gray, install `roxygen2` (`install.packages("roxygen2")`).



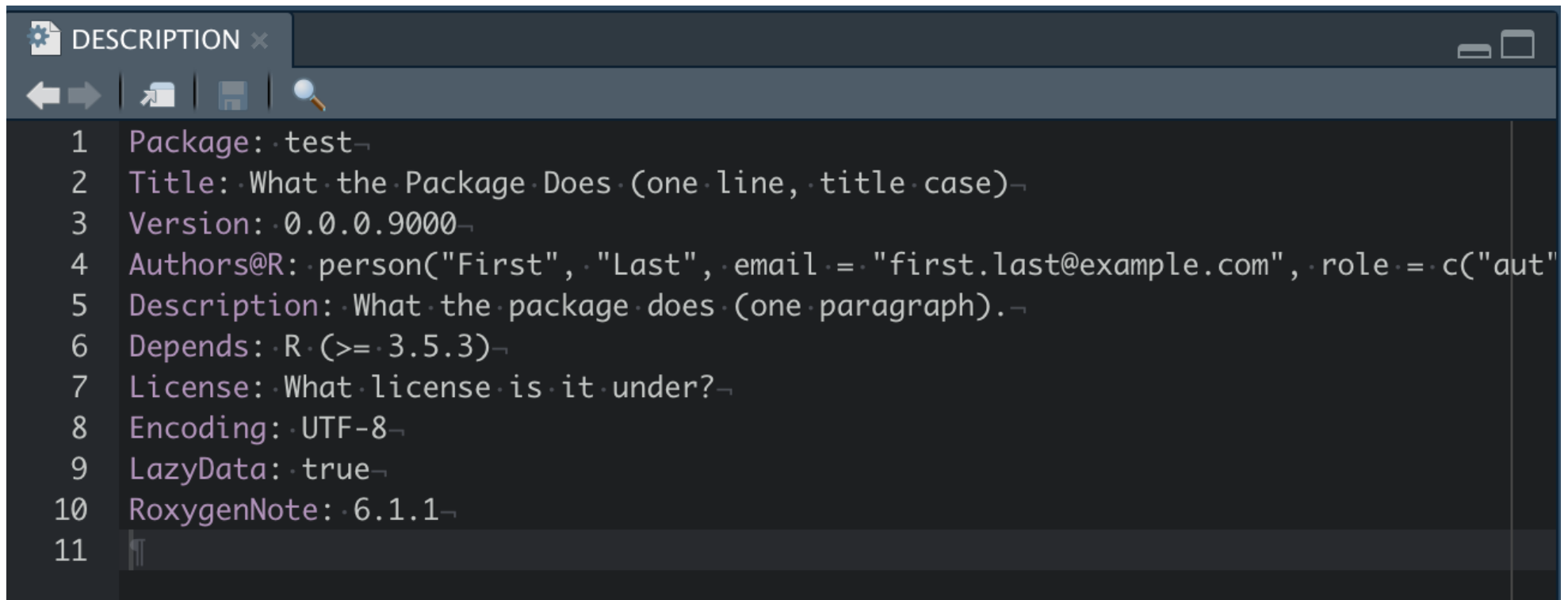
DESCRIPTION file



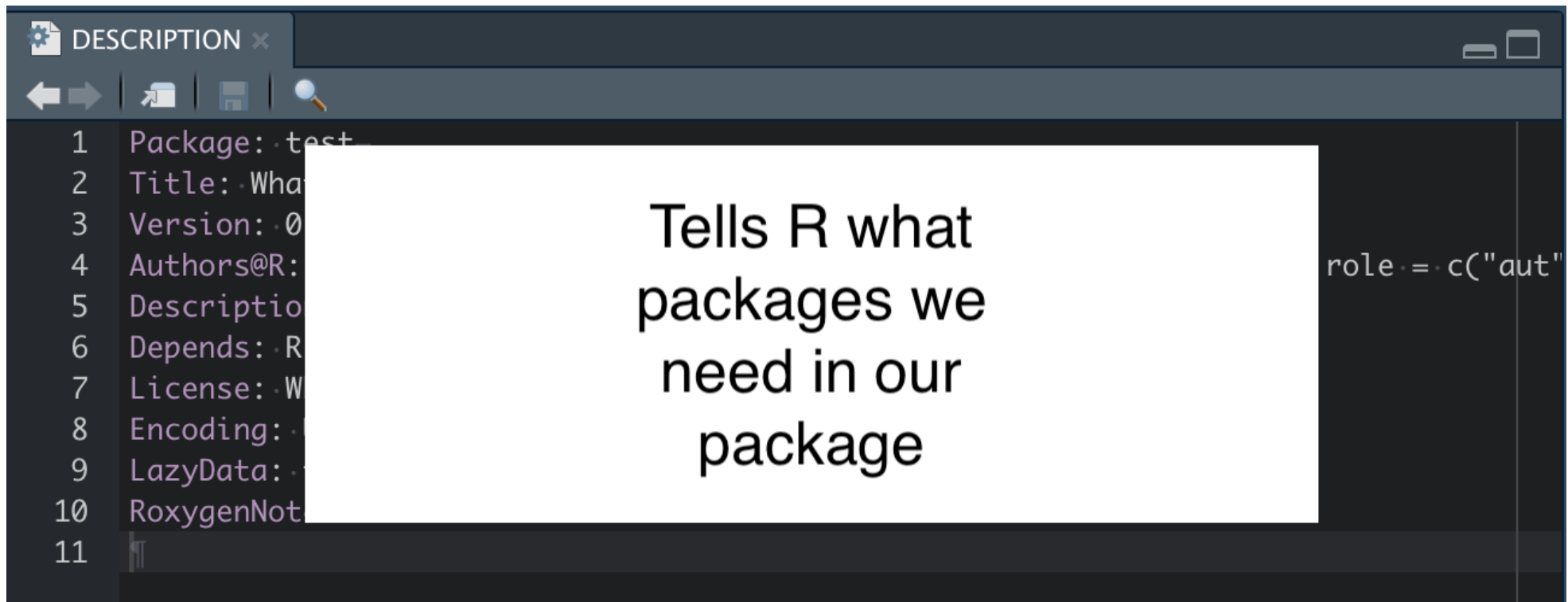
In the RStudio project, go to “Go to file/function” search bar on the menu bar. Also `Ctrl + .` on Mac.

- This searches through the files in the package.
 - Also searches for **function names** and can go to that function in the file

Type `DESCRIPTION` and open that file.

A screenshot of a code editor window titled 'DESCRIPTION'. The window has a dark theme and a toolbar with icons for back, forward, save, and search. The main area contains a DESCRIPTION file with the following content:

```
1 Package: test
2 Title: What the Package Does (one line, title case)
3 Version: 0.0.0.9000
4 Authors@R: person("First", "Last", email = "first.last@example.com", role = c("aut"
5 Description: What the package does (one paragraph).
6 Depends: R (>= 3.5.3)
7 License: What license is it under?
8 Encoding: UTF-8
9 LazyData: true
10 RoxygenNote: 6.1.1
11
```



DESCRIPTION

```
1 Package: test
2 Title: What
3 Version: 0.0.0
4 Authors@R:
5 Description:
6 Depends: R (
7 License: W
8 Encoding:
9 LazyData:
10 RoxygenNot
11
```

Tells R what
packages we
need in our
package

role = c("aut"

DESCRIPTION: Package Title

Change the `Title` so that it's Title Case and make sure to put single quotes around weird words (like science-specific).

```
Title: How to Analyze Data and Images
```

```
Title: Analyze Data from 'ENAR'
```

- do **not** start with R package or Package

DESCRIPTION: Description

Change the `Description` so that it's a sentence (prose) and it ends with a period.

Also I keep putting single quotes around weird words (like science-specific). Make sure to put links in angle brackets (`<http...>`).

Use DOIs if you can (`<doi...>`). If you go too long on a line, indent it with 4 spaces and go to the next.

```
Description: Provides tools for 'ENAR' 2020 meeting
<https://enar.org/meetings/spring2020/>. Provides slides for R
package development.
```

DESCRIPTION: additional fields

- **Imports:** package1, package2
 - packages with functions we need in code
- **Depends:** dplyr, enar2020
 - ALL functions loaded from package, but loaded in user library before your package
 - Similar to `library(dplyr); library(enar2020)` - *not recommended*
- **Suggests:** package4, package6: used in examples or vignettes

DESCRIPTION: not so fun default

In the RStudio build, it may add something like:

```
Depends: R (>= 3.6.2)
```

This is not great because anyone with a lower R version (like 3.4) cannot install your package. Unless you need the newest R functionality, delete this line.

Authors

I add this to the DESCRIPTION file (and remove Author: field):

```
Authors@R: person(given = "John",  
  family = "Muschelli",  
  role = c("aut", "cre"),  
  email = "muschellij2@gmail.com",  
  comment = c(ORCID = "0000-0001-6469-1750"))
```

Authors

I use `Authors@R` even if there is only one author because of the `desc` [package issue](#) and that package is relied upon for site building and stuff later.

Roles, see `?person`

- `cre` - creator/maintainer, can only have one
- `aut` = author, can have multiple



Maintainer

If you use `Authors@R`, you should be able to remove the `Maintainer` field, but I don't. I am explicit about `Maintainer` because some people use that field as some parsers use `Author` and not `Authors@R`.

Maintainer: John Muschelli <muschellij2@gmail.com>

License

I use License: GPL-3 or GPL-2 See <https://www.r-project.org/Licenses/>.

```
usethis::use_gpl3_license()  
usethis::use_mit_license()
```

https://kbroman.org/pkg_primer/pages/licenses.html

Documenting Your Package

Roxygen2

Roxygen allows for functions and documentation in the same file. Copy/Paste or [Download here](#).

```
top = function(x, n) {  
  xx = x[1:n, 1:n]  
  hist(xx)  
  print(xx)  
}
```

Save this to `top.R` file in `R/` (where R functions are).
Delete `hello.R` file if present.

Function names should likely be verbs, though (e.g. `get_top`)

Adding a package to DESCRIPTION field

Say you want to use `dplyr` functions for your code:

```
usethis::use_package("dplyr")
```

but what if you did this instead? (Function masking)

```
usethis::use_package("dplyr", type = "Depends")
```

You Want the Pipe but not `dplyr`

Add the pipe (`%>%`) to a package

```
usethis::use_pipe()
```

```
#' Pipe operator
#'
#' See \code{magrittr::\link[magrittr:pipe]{\%>\%}} for details.
#'
#' @name %>%
#' @rdname pipe
#' @keywords internal
#' @export
#' @importFrom magrittr %>%
#' @usage lhs \%>\% rhs
NULL
```

Creating a roxygen header

Highlight the following code:

```
top = function(x, n) {
```

Go to Code -> Insert Roxygen Skeleton

Roxygen header

Roxygen header (what turns into a help file):

```
#' Title
#'  
#' @param x  
#' @param n  
#'  
#' @return  
#' @export  
#'  
#' @examples
```

Roxygen tags

- `@param` stands for a parameter/argument for that function.
- `@return` denotes what the function returns. This is required.

Roxygen tags

- `@export` - when people install your package, can they use this function
 - non-exported functions are usually helpers, really small, or not fully formed yet
 - `@examples` - code to show how the function works. Wrap functions in `\dontrun{ }` if not wanted to run and `\donttest{ }` for not testing
 - make sure `\dontrun{ }` **not** `\dontrun { }` (spaces fail)

Full roxygen header

```
#' Print the top of a matrix
#' @param x a \code{matrix}
#' @param n Number of rows and columns to display of the matrix
#'
#' @return A \code{NULL}
#' @export
#'
#' @examples
#' mat = matrix(rnorm(100), nrow = 10)
#' top(mat, n = 4)
#' \dontrun{
#'   top(mat, n = 10)
#' }
```

Roxygen header: title/description unique

Instead of `Title`, you can use separate `@title` and `@description` tags if you want them to be different. For example:

```
#' @title Print the top of a matrix  
#' @description \code{top} is a small function to not just present the first rows
```

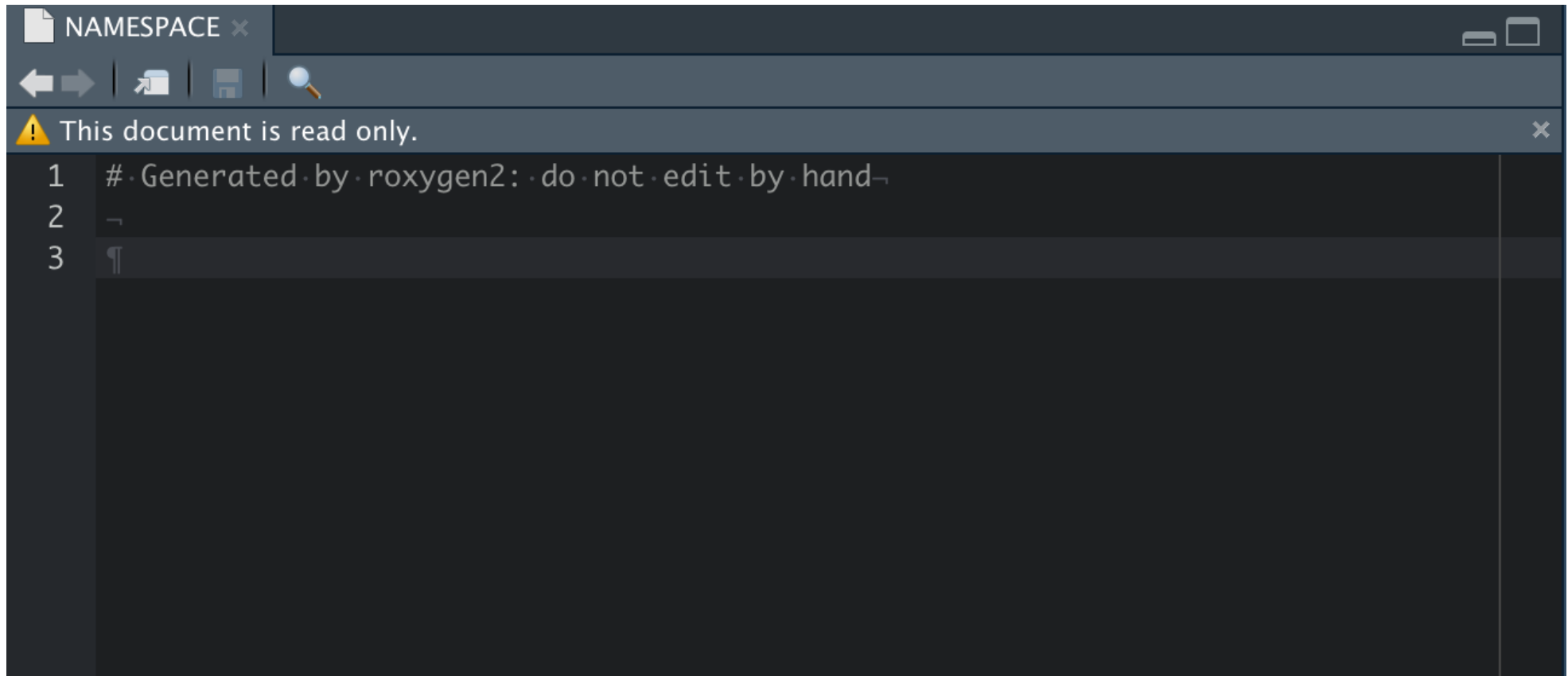

Roxygen and Markdown

If you want to use `markdown` with `roxygen2`, then you can use

```
usethis::use_roxygen_md()
```

so instead of `\code{top}` you can write ``top`` from the previous slide.

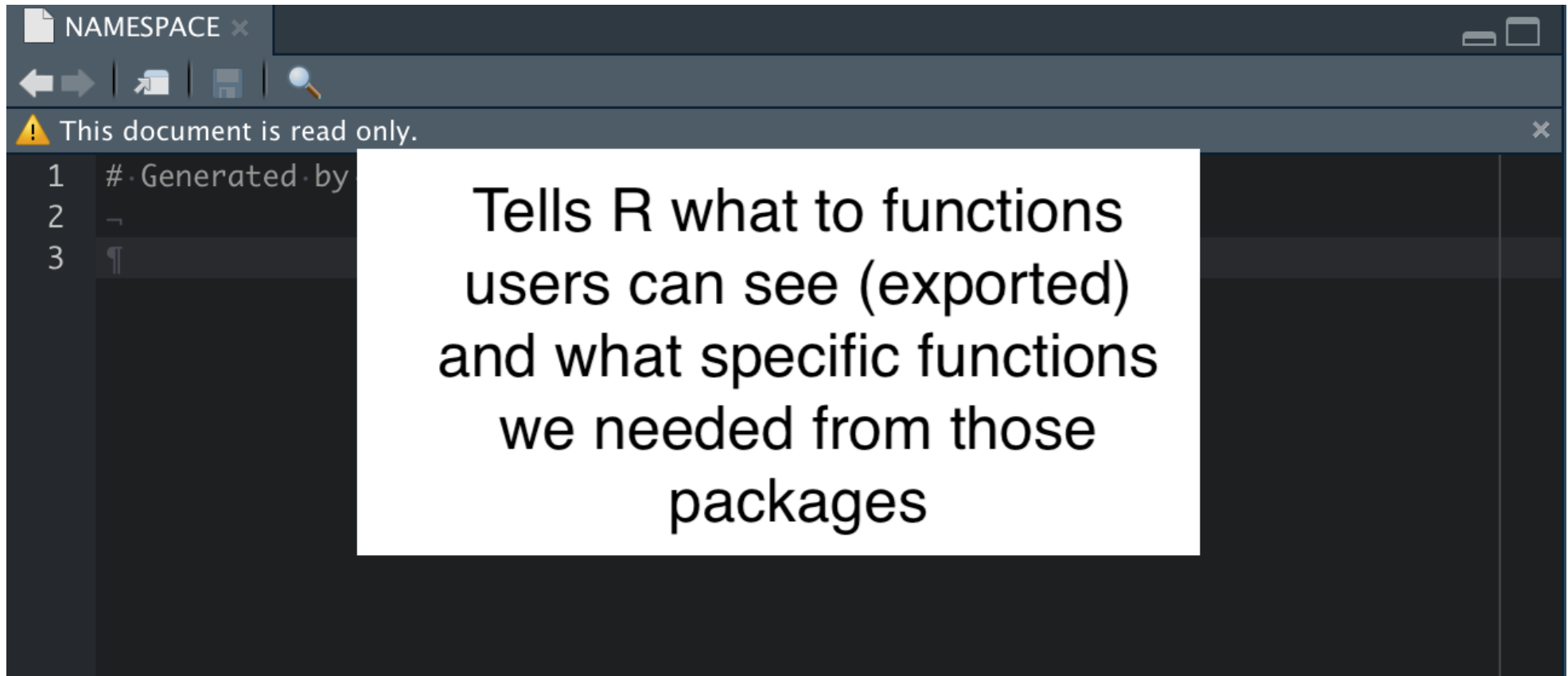
NAMESPACE



The screenshot shows a code editor window with a dark theme. The title bar at the top reads 'NAMESPACE' with a close button. Below the title bar is a toolbar with icons for back, forward, undo, redo, and search. A yellow warning icon is present on the left side of the editor area, with the text 'This document is read only.' and a close button on the right. The editor area contains a single line of code on line 1: `# Generated by roxygen2: do not edit by hand`. Lines 2 and 3 are empty. The code is in a light gray font on a dark background.

```
1 # Generated by roxygen2: do not edit by hand
2
3
```

NAMESPACE



Building the NAMESPACE with roxygen

In Roxygen:

- `@export` - adds this to the NAMESPACE file
 - when package is installed, users can call this function

Building the NAMESPACE with roxygen

In Roxygen:

- `@import` - imports **ALL** functions from that package
 - if package is listed under Depends in DESCRIPTION, then the **whole package** is loaded when you load your package
 - otherwise it simply exposes them for your package to use them, but not the user, users still have to do `library(PACKAGENAME)`

You do not have **library()**
functions in R package code

Check

Go to Build → Check Package. You should see something like:

```
top: no visible global function definition for 'hist'
Undefined global functions or variables:
  hist
Consider adding
  importFrom("graphics", "hist")
to your NAMESPACE file.
```

**The Goal is to have NO
Errors/Warnings/Notes on R CMD
Check**

Why the Message?

R sees `hist` from `graphics`, but we never told it we needed it

You *should* import anything explicitly other than from the `base` package, including anything from `stats` (e.g. `quantile`) or `graphics` (e.g. `hist`). Don't import `base`.

Importing Packages or Functions from Packages

- `@importFrom` - if you want to import a **function**, you say `@import PACKAGE_NAME func1 func2`
 - only imports these functions (preferred to `@import`)
 - if `pkgA` has function `A` and `pkgB` has functions `A` and `B`, if `@import pkgA A, @import pkgB B`, then if you call `A()`, R knows it's from `pkgA`
 - But should use `pkgA::A()` in practice

Fixing the Message

Add `@importFrom graphics hist` to your `top.R` file
(anywhere in the header)

- RStudio: Build → Check Package again

Importing Package Functions

- You only have to import a whole package or a package function, don't mix and match
- You only have to import a function in **one** file.
- e.g `put @importFrom graphics hist` in any `.R` file.
- Any package you want to import, make sure you use `use_package`, so we'd use:

```
usethis::use_package("graphics")
```

Build and Reload Again

- RStudio: Go to `Build` → `Build and Reload` the package
 - First time you may see some warnings (no NAMESPACE file!)
 - Rerunning may get rid of these
- Then try `Build` → `Check Package`

Troubleshooting

In case things are not working or seem off

- Delete the `NAMESPACE` file. If building fails, add an empty file with

```
# Generated by roxygen2: do not edit by hand
```

at the top and rerun. - Delete the `man` folder - `roxygen2` will create the documentation automatically

Including Data

- Data should be small, but good for running examples or vignettes.

Run `use_data_raw()` if you have code to generate data (R data):

```
usethis::use_data_raw("mydata_set")
```

This will create a `data-raw` folder.

Including Data

Let's say you want to make a data set `mydata_set`:

Create `data-raw/mydata_set.R` and at the end, run

```
usethis::use_data(mydata_set, compress = "xz")
```

And this will make a `data/mydata_set.rda` file.

Documenting Data

- You don't need to put an `export` tag for data.

```
#' My Awesome Data Set
#'  
#' A more detailed description  
#'  
#' @format A `data.frame` with 2 columns elements, which are:  
#' \describe{  
#' \item{x1}{column of x variables}  
#' \item{y2}{column of yvariables}  
#' }  
"mydata_set"
```

Including Non-R data

If you want to include other types of data (such as images) put them into the `inst/` folder (or a subfolder of `inst`, I recommend `extdata`). You can access them using `system.file` when installed.

For example, if you have a file
`inst/extdata/myimage.nii.gz`:

```
system.file("extdata", "myimage.nii.gz", package = "YOUR_PACKAGE_NAME")
```

will return the filename for you to access it in code.

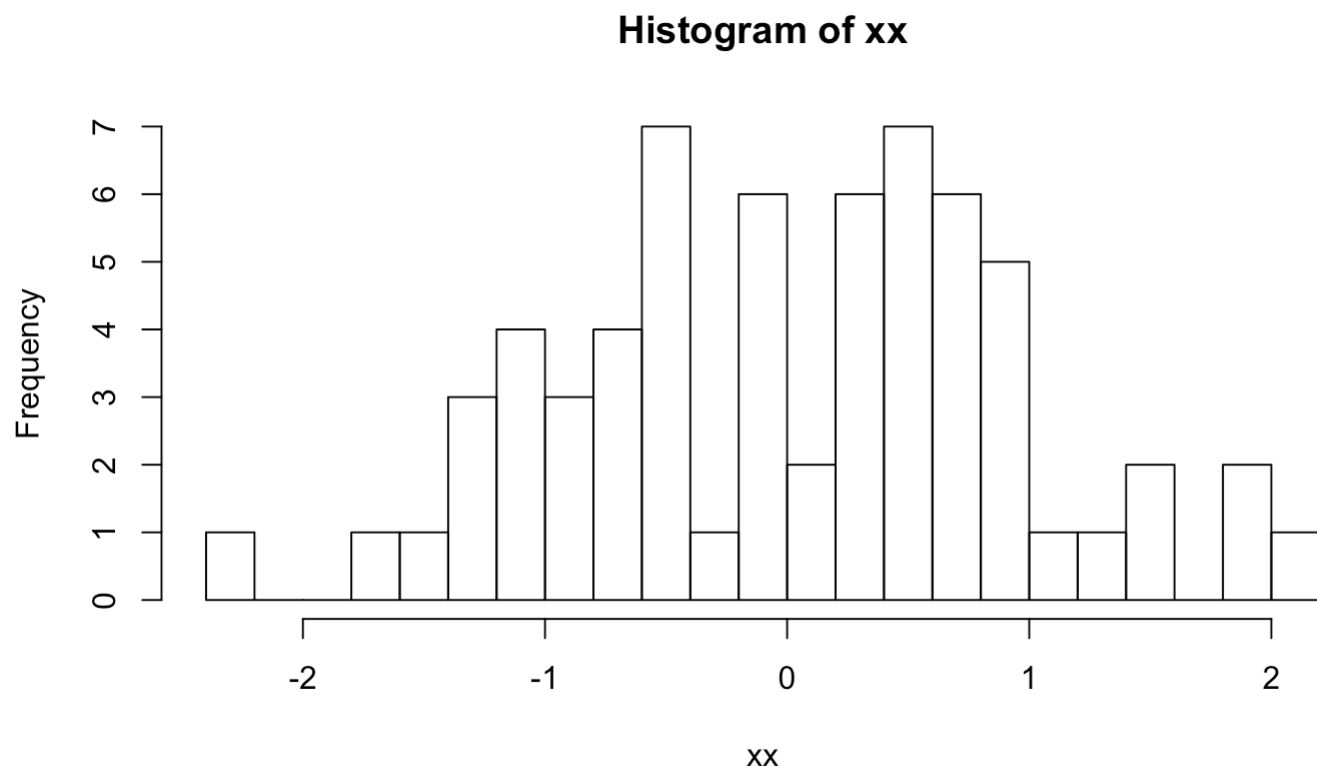
Passing arguments “through”

The ellipsis/dots `...` can pass arguments through to other methods:

```
#' @rdname top
#' @export
#' @param ... pass additional methods to [graphics::hist]
top_with_dots = function(x, n, ...) {
  xx = x[1:n, 1:n]
  hist(xx, ...)
  print(xx)
}
```

Passing arguments “through”

```
top_with_dots(matrix(rnorm(100), nrow = 10), n = 8, breaks = 20)
```



	[,1]	[,2]	[,3]	[,4]	[,5]	[,6]
[1,]	-0.8746819	0.43070060	-1.78152974	-0.4608630	-0.5550150	0.2353034
[2,]	0.5338362	-0.08362546	-0.60826410	-0.7200107	-1.3092591	0.3528392

Picking one option and Checking for input

`match.arg` will return *one* option from a set of them.

```
run_top_stat = function(x, n = 4, stat = c("mean", "median", "sd"), ...) {  
  stat = match.arg(stat)  
  print(stat)  
  if (!assertthat::is.number(n)) { # make sure n is just one value and numeric  
    stop("n should be a number of length 1!")  
  }  
  top_x = top_with_dots(x, n = n, ...)  
  func = switch(stat, mean = function(x) mean(x, na.rm = TRUE),  
                "median" = median, "sd" = sd)  
  return(func(top_x))  
  stop("this will never be executed!")  
}
```

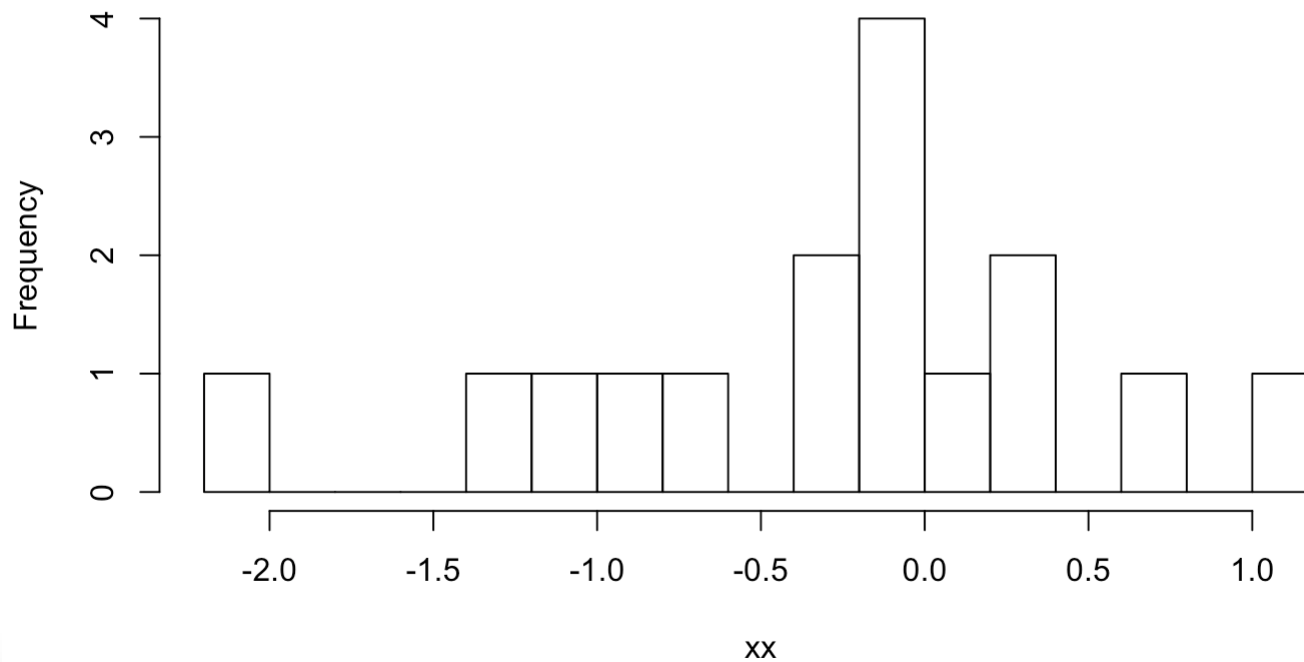
R run `usethis::use_package("assertthat", "Imports")` as we are now using `assertthat` package.

Picking one option

```
run_top_stat(matrix(rnorm(100), nrow = 10), breaks = 20)
```

```
[1] "mean"
```

Histogram of xx



“Printing” Output and Checking for Input

`print` is fine when debugging, but use `message` and `suppress` option

```
run_top_stat = function(x, n = 4,
                        stat = c("mean", "median", "sd"), verbose = TRUE, ...) {
  stat = match.arg(stat)
  if (verbose) {
    message(paste0("Statistic is ", stat))
  }
  if (!assertthat::is.number(n)) { # make sure n is just one value and numeric
    stop("n should be a number of length 1!")
  }
  top_x = top(x, n = n, ...)
  func = switch(stat, mean = function(x) mean(x, na.rm = TRUE),
                "median" = median, "sd" = sd)
  return(func(top_x))
}
```

Optional arguments

Many times I will set something to `NULL` and then test to determine logic

```
gen_func = function(x, y = NULL) {  
  if (!is.null(y)) {  
    x = x * y  
  }  
  plot(x)  
}
```


Unit Tests

Unit testing packages: `testthat` and `RUnit`.

To use `testthat`, run `usethis::use_testthat()`. All test files must be in `testthat/tests/` and must start with the word `test`.

```
testthat::test_that("Description of test", {  
  # code for test  
  r = 3.5523334  
  df = data.frame(r = r)  
  testthat::expect_equal(r, 3.5523334)  
  testthat::expect_true(r > 3)  
  testthat::expect_error(r + "hey")  
  testthat::expect_is(df, "data.frame")  
})
```

Good Rule of Thumb: Any issue created/bug found gets a test

If used in a paper, make sure tests
check paper results

What to test

- Object output type (list/data.frame)
- Expected output value (3.233453)
- Multiple inputs give expected output
- Even graphs: <https://github.com/r-lib/vdiffr>

Creating Vignettes

```
usethis::use_vignette("my-vignette")
```

title is on the document, VignetteIndexEntry is on the website:

```
---  
title: "my-vignette"  
output: rmarkdown::html_vignette  
vignette: >  
  %\VignetteIndexEntry{my-vignette}  
  %\VignetteEngine{knitr::rmarkdown}  
  %\VignetteEncoding{UTF-8}  
---
```

95% of what you will be need.
Mostly it will be documenting and
examples

Creating a README

```
usethis::use_readme_rmd()
```

This will create a `README.Rmd` file for your GitHub/Package.

- GitHub renders the README.
- Instructions on how to use the package (examples)
- Instructions on installing 3rd-party dependencies

Spell Checking

Believe it or not, CRAN will check some spelling.

```
devtools::spell_check()
```

after you have fixed the issues, run

```
spelling::update_wordlist()
```

to make a WORDLIST file. These are correctly spelled but likely jargon.

Creating NEWS.md

```
usethis::use_news_md()
```

This will create a `NEWS.md` file to update with new versions of the package, discussing changes (CRAN Requires).

```
package 0.2.0
```

- Added function ``get_data``
- Fixed bug in ``bad_function`` (fixes issue #52).

Continuous Integration

Continuous Integration: Testing on the Cloud

- Travis tests Linux/OSX and Appveyor tests Windows
- Integrate with GitHub, each push tested

```
usethis::use_git() # done if using devtools  
usethis::use_github() # must have GITHUB_PAT set up  
usethis::use_appveyor()  
usethis::use_travis()
```

appveyor.yml

Add the following lines:

```
environment:  
  global:  
    WARNINGS_ARE_ERRORS: 1
```

to appveyor.yml to make sure warnings are treated as errors.

Code Coverage

- Code coverage is the percentage of code (without whitespace) which is covered by automated tests.
- Calculated using covr package.
- I tend to check coverage by examples, vignettes and tests vs. just tests (default).
- You can run `covr::package_coverage(type = "all")` locally.

Code Coverage with Continuous Integration

- Run `usethis::use_coverage()`, with either coveralls or codecov.
 - Add lines to `.travis.yml` if necessary

Releasing to CRAN

- Push all changes to GitHub.
- `usethis::use_cran_comments()`
- Try your package on [rhub](#) with `devtools::check_rhub()`
- Run on CRAN Windows build `devtools::check_win_devel()`
- Run `devtools::release(check = TRUE)` and go through the steps
- Validate the email from CRAN for submission.

This is just a starting point

- A lot of additional things we can discuss individually
- <https://cran.r-project.org/doc/manuals/r-release/R-exts.html>, though huge, should cover “everything”
- Most of the work is documentation (80%) and vignettes and tests (20%)

Extra Slides

Making a Website

- `pkgdown` makes nice doc pages for your package
- Run `usethis::use_pkgdown()`. Then run `pkgdown::build_site()`.
- Push everything to GitHub.
- Go to GitHub repo → Settings → Scroll down to “GitHub Pages”, set Source to `master branch /docs folder`
- Refresh your webpage.

No visible binding for global variable issue

If you get `No visible binding for global variable`, you're likely using Non-Standard Evaluation (NSE) or tidy evaluation

No visible binding for global variable issue

2 options, follow different approaches:

1. [Use globalVariables](#)

2. Let's say `col5` is the global variable. At top of function write:

```
col5 = NULL # set to something  
rm(list = "col5") # remove it
```

This will remove it but not be a “global” fix. Also, make sure `col5` is **not** an argument in your function

Skipping tests on CRAN/CI

- Use `testthat::skip_on_cran()` for skipping CRAN tests
- `testthat::skip_on_travis()` and `testthat::skip_on_appveyor()` for CI

Making a Logo/Hex Sticker

Install the hexSticker package

```
library(hexSticker)
library(desc)
desc = desc::description$new()
fig_dir = file.path("man", "figures")
if (dir.exists(fig_dir)) {
  dir.create(fig_dir, recursive = TRUE)
}
package = desc$get("Package")
hexSticker::sticker(
  package = package,
  # add code here
  filename = file.path(fig_dir, "sticker.png"))
usethis::use_logo(file.path(fig_dir, "sticker.png"))
```