Testing Testing!

Obviously we all test our code ☺ but can we do it more efficiently? This talk is a brief introduction (I'm no expert!) on how to write formal, automated tests.

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Testing…

- We all know why we need to test our code – especially for mathematical models which may be 1000s of lines of code
- How do we go about this?
  - The results look “about right”
    - Two wrongs can make a right!
  - Compare with data
    - this tests the whole thing but not the individual parts
    - Some data sets will not trigger various parts of a model
  - We often test a function when we write it but these tests are informal and easily lost

Unit tests – what?!

These can test one function at a time in a very simple way

A unit test tests the expected output from a function, i.e. we expect certain inputs to give a certain answers.

Example (paired down!)

```
f(x) = function(x){2*x}

expect_equal(f(3),6)

expect_true(f(1)>1)

expect_length(f(1),1)

expect_gt(length(f(c(1,2,3))),1)

expect_error(f('x'))
```

Unit tests – why?

- Unit tests are stored formally and run in automated way – this stops you endlessly repeating stuff you've already done
- They can all be run at once or separately
- They can be tested for extremes i.e. when the inputs are not what you expect them to be – writing unit tests can be combined with adding error-catching to your code
- If we come to add a feature or reorganise/restructure (i.e. refactor) our code we can run our unit tests and be safe in the knowledge we haven't broken it all!
- Writing tests often helps you to massively improve your code as it forces you to break your code down into testable chunks.
- When you come to share your code (hello, Open Science!) you can feel more confident about it!

Unit tests – how?

- I will focus on unit testing in R but the principles will apply to other languages

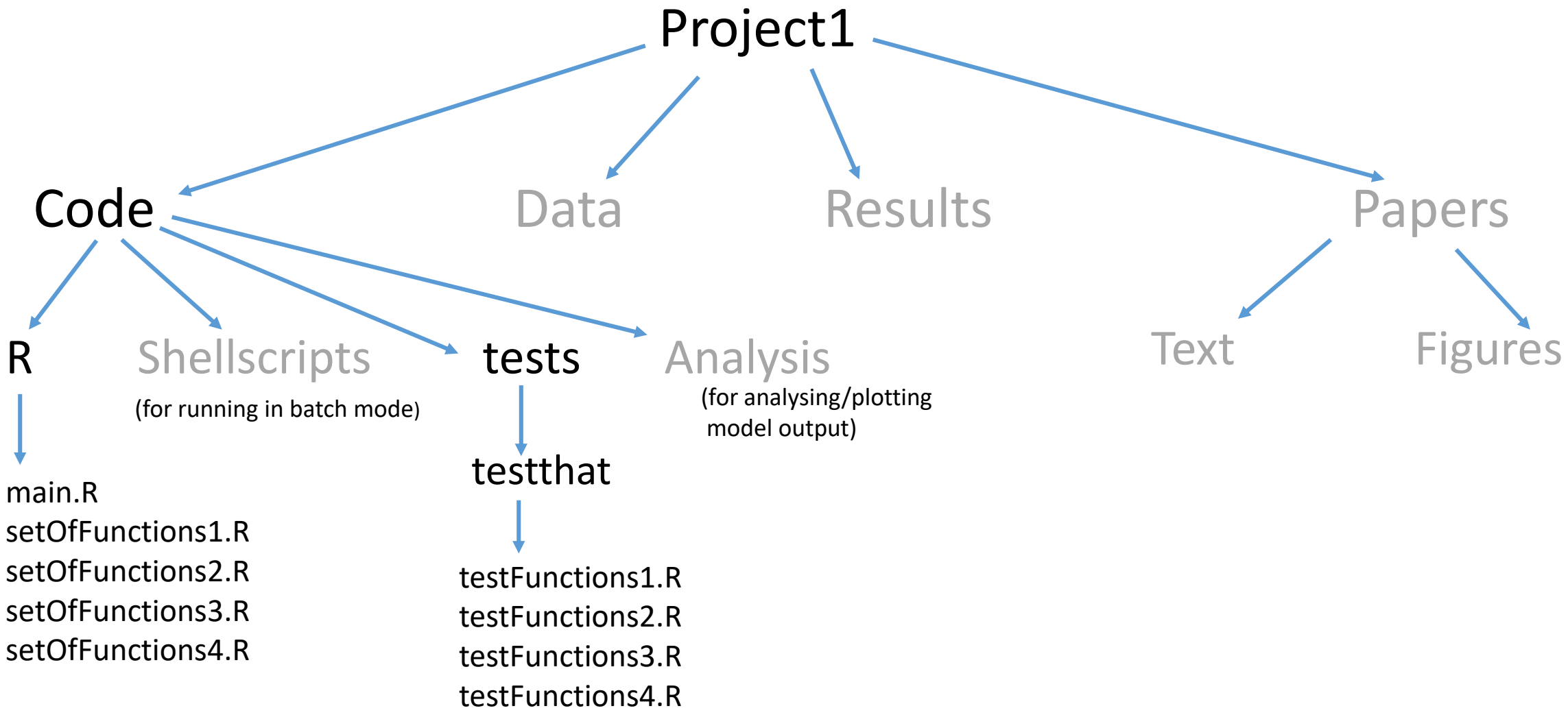
- Resource: https://r-pkgs.org/tests.html

- In R there is a library called testthat – install.packages('testthat')
- This allows you to write and run your unit tests

- I think creating the folders etc can all be automated (use package called "usethis") but I do it by hand as I'm a control freak

  - you need a folder called 'tests' and within that a folder called 'testthat' and then you put in any number of files which contain any number of unit tests.

Organising


Project1
Code
Data
Results
Papers
R
Shellscripts
(for running in batch mode)
tests
Analysis
(for analysing/plotting model output)
Text
Figures
main.R
setOfFunctions1.R
setOfFunctions2.R
setOfFunctions3.R
setOfFunctions4.R
testthat
testFunctions1.R
testFunctions2.R
testFunctions3.R
testFunctions4.R

testFunctions1.R

```
library(testthat)
source('../../R/setOfFunctions1.R')

X=1
Y=2
test_that('function1',{
        expect_equal(f1(X,Y),-2)
        expect_length(f1(X,Y),1)
})

Z=3
test_that('function2',{
        expect_equal(f1(X,Y,Z),6)
        expect_true(f1(X,Y,Z)>0)
})
```

You can then simply run this script i.e.

```
setwd('testthat')
source('testFunctions1.R')
```

When you run the tests you get a message and the details for any failed tests

Examples of expectations you can test

https://testthat.r-lib.org/reference/index.html

Objects	
expect_equal() expect_identical()	Does code return the expected value?
expect_type() expect_s3_class() expect_s4_class()	Does code return an object inheriting from the expected base type, S3 class, or S4 class?
Vectors	
expect_length()	Does code return a vector with the specified length?
expect_lt() expect_lte() expect_gt() expect_gte()	Does code return a number greater/less than the expected value?
expect_named()	Does code return a vector with (given) names?
expect_setequal() expect_mapequal()	Does code return a vector containing the expected values?
expect_true() expect_false()	Does code return TRUE or FALSE?
expect_vector()	Does code return a vector with the expected size and/or prototype?
Side-effects	
expect_error() expect_warning() expect_message() expect_condition()	

Functions for running tests

Run tests

auto_test()	Watches code and tests for changes, rerunning tests as appropriate.
auto_test_package()	Watches a package for changes, rerunning tests as appropriate.
describe()	describe: a BDD testing language
test_file()	Run all tests in a single file
test_package() test_check() test_local()	Run all tests in a package
test_path()	Locate file in testing directory.
test_that()	Run a test
use_catch()	Use Catch for C++ Unit Testing

Summary

- You don’t need to be building an R package to formally test your code
- You can write as many or as few tests as you like
- You can run them whenever you like
- You can automate all this using testthat, devtools, usethis
  - This will make it easier than I have shown but it’s good to understand the fundamentals I think!☺
  - I often make plots in my test files too but would comment these out for packaging
- There are a lot of online resources – google: ‘unit tests R’, ‘testthat’, ‘creating packages in R’ etc.
- Caveat – I am not an expert (just a self-taught hacker!) – ask David and Bram for better info!
- Happy testing!