Introduction to R

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What you’ll learn about

- What is R?
- What’s possible with R?
  - CRAN and packages
- R basics
  - Installation
  - Command-line interface
  - Coding basics
  - Functions and objects
  - Data import and manipulation
- Help!
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- What’s possible with R?
  - CRAN and packages
- R basics
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  - Coding basics
  - Functions and objects
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- Help!

Interactive!
What is \( R \)?

R is a language and environment for statistical computing and graphics \([r-project.org]\)
What is R?

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R is a computer language that allows the user to program algorithms and use tools that have been programmed by others [Zuur et al. 2009]
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Different from other statistics software because it is also a programming language...
What is R?

R is both... this creates a steep learning curve.
What is R?

R is becoming the statistical software of choice

Plot of Google scholar hits over time for different software packages [r4stats.com]
What is \( \mathbf{R} \)?

R is becoming the statistical software of choice.

Exponential growth in number of contributed packages [r4stats.com]
What’s possible with R?

R is incredibly flexible, if you want something done, someone else has written the code...
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CRAN is a collection of sites which carry identical material, consisting of the R distribution(s), the contributed extensions, documentation for R, and binaries \[\text{R FAQ}\]
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Basically a repository of R utilities that others have written
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Basically a repository of R utilities that others have written - the CRAN task views contain descriptions of contributed packages by category
CRAN Task Views

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bayesian</td>
<td>Bayesian Inference</td>
</tr>
<tr>
<td>ChemPhys</td>
<td>Chemometrics and Computational Physics</td>
</tr>
<tr>
<td>ClinicalTrials</td>
<td>Clinical Trial Design, Monitoring, and Analysis</td>
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<td>Cluster</td>
<td>Cluster Analysis &amp; Finite Mixture Models</td>
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<tr>
<td>DifferentialEquations</td>
<td>Differential Equations</td>
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<tr>
<td>Distributions</td>
<td>Probability Distributions</td>
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<tr>
<td>Econometrics</td>
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<tr>
<td>Environmetrics</td>
<td>Analysis of Ecological and Environmental Data</td>
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<td>ExperimentalDesign</td>
<td>Design of Experiments (DoE) &amp; Analysis of Experimental Data</td>
</tr>
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<td>Finance</td>
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<td>Graphics</td>
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<td>HighPerformanceComputing</td>
<td>High-Performance and Parallel Computing with R</td>
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<tr>
<td>MachineLearning</td>
<td>Machine Learning &amp; Statistical Learning</td>
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<tr>
<td>MedicalImaging</td>
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<td>MetaAnalysis</td>
<td>Meta-Analysis</td>
</tr>
<tr>
<td>Multivariate</td>
<td>Multivariate Statistics</td>
</tr>
</tbody>
</table>
What’s possible with \( R \)?

CRAN Task View: Analysis of Ecological and Environmental Data

**Maintainer:** Gavin Simpson  
**Contact:** ucfagls at gmail.com  
**Version:** 2013-04-12

**Introduction**

This Task View contains information about using R to analyse ecological and environmental data.

The base version of R ships with a wide range of functions for use within the field of environmetrics. This functionality is complemented by a plethora of packages available via CRAN, which provide specialist methods such as ordination & cluster analysis techniques. A brief overview of the available packages is provided in this Task View, grouped by topic or type of analysis. As a testament to the popularity of R for the analysis of environmental and ecological data, a special volume of the *Journal of Statistical Software* was produced in 2007.

Those users interested in environmetrics should consult the Spatial view. Complementary information is also available in the Multivariate, Phylogenetics and Cluster task views.

If you have any comments or suggestions for additions or improvements, then please contact the maintainer.

A list of available packages and functions is presented below, grouped by analysis type.
What’s possible with \texttt{R}?

R has a base package that is included in installation, others are downloaded as needed

\begin{verbatim}
> install.packages('newpackage')
\end{verbatim}

The base package will be sufficient for most of your needs - includes arithmetic, input/output, basic programming support, graphics, etc.

Contributed packages will meet your other needs - now exceed 4000
What’s possible with R?

> demo(package = .packages(all.available = TRUE))

List of demonstrations with available packages - examples from ggplot2 package

![Distribution of Gas Mileage](image1)

![Regression of MPG on Weight](image2)
What’s possible with R?

```r
> demo(package = .packages(all.available = TRUE))
```

List of demonstrations with available packages - examples from ggplot2 package

![Graph showing mileage by gear number](image)
basics

Installation - visit r-project.org and follow directions

The Comprehensive R Archive Network

Download and Install R

Precompiled binary distributions of the base system and contributed packages, Windows and Mac users most likely want one of these versions of R:

- Download R for Linux
- Download R for (Mac) OS X
- Download R for Windows

R is part of many Linux distributions, you should check with your Linux package management system in addition to the link above.

Source Code for all Platforms

Windows and Mac users most likely want to download the precompiled binaries listed in the upper box, not the source code. The sources have to be compiled before you can use them. If you do not know what this means, you probably do not want to do it!

- Sources of R alpha and beta releases (daily snapshots, created only in time periods before a planned release).
- Daily snapshots of current patched and development versions are available here. Please read about new features and bug fixes before filing corresponding feature requests or bug reports.
- Source code of older versions of R is available here.
- Contributed extension packages
Or visit Rweb for an online version (not recommended)

Introduction

This server allows the use of two packages developed in our Lab for the R software: ade4 and seqinr.

The documentation of the ade4 package is available here, and the documentation of the seqinr package is available here. Note that on this server, these two packages are automatically loaded each time R is launched, so you do not need to use the library(ade4) and library(seqinr) commands (but using them will not hurt).

To run Rweb just type the code you want to execute into the text window below and then click on the submit button. You will get a new html page with the text output of your code followed by the graphical output (if any) from your code. A detailed example of use is here. It shows how you can use this system to search sequence data banks for gene sequences, compute the codon frequencies for these genes, and perform a correspondence analysis of this data table.

You can try examples from the ade4 package by just clicking the Submit button with the examples below. Just remove these lines to type your own code. The computer time for all of this is donated by the PBIL. Please note that all actions are logged and that abuse will lead to exclusion of IP addresses.

data(meaudret)
pca1=dudi.pca(meaudret$env, scan=F) scatter(pca1) s.ball(pca1$co) s.label(pca1$li) score(pca1) s.class(pca1$li, meaudret$plan$sta, col=c("black", "red", "green", "blue", "purple"))
A text editor is highly recommended, e.g. RStudio
basics

How is R different from Excel?
basics

How is R different from Excel? R is a command-line interface

R version 2.15.2 (2012-10-26) -- "Trick or Treat"
Copyright (C) 2012 The R Foundation for Statistical Computing
ISBN 3-900051-07-0
Platform: x86_64-w64-mingw32/x64 (64-bit)

R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.

Natural language support but running in an English locale

R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

> |
How is R different from Excel? R is a command-line interface

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What next??
Lines of code are executed by R at the prompt (>

```r
print('hello world!')
```

```
[1] "hello world!"
```

```r
2+2
```

```
[1] 4
```

```r
(2+2)/4
```

```
[1] 1
```

```r
rep("a",4)
```

```
[1] "a" "a" "a" "a"
```
Lines of code are executed by R at the prompt (>)

Enter the code and press enter, the output is returned

> print('hello world!')
[1] "hello world!"
> 2+2
[1] 4
> (2+2)/4
[1] 1
> rep("a",4)
[1] "a" "a" "a" "a"
A disadvantage of code is that everything entered must be 100% correct.

```r
> 2+2a
```

Error: unexpected symbol in "2+2a"

```r
> a
```

Error: object 'a' not found
A disadvantage of code is that everything entered must be 100 % correct

> 2+2a

Error: unexpected symbol in "2+2a"

> a

Error: object 'a' not found

But this enables a complete documentation of your workflow...

...your code is a living document of your analyses.
Assigning data to R objects is critical for analysis

```r
> a <- 1
> 2 + a
[1] 3

> a <- 1
> 2 + a
[1] 3

> a <- 2 + 2
> a / 4
[1] 1
```
Assigning data to R objects is critical for analysis

Assignment is possible using `<-` or `=`

```r
> a <- 1
> 2 + a
[1] 3
> a = 1
> 2 + a
[1] 3
> a = 2 + 2
> a / 4
[1] 1
```
Assigning data to R objects is critical for analysis

More complex assignments are possible

```r
> a <- c(1, 2, 3, 4)
> a
[1] 1 2 3 4
> a <- seq(1, 4)
> a
[1] 1 2 3 4
> a <- c("a", "b", "c")
> a
[1] "a" "b" "c"
```
Anatomy of a function - functions perform tasks for you, much like in Excel

\( \text{function( arguments )} \)
Anatomy of a function - functions perform tasks for you, much like in Excel

function(arguments)

> c(1,2) #concatenate function
[1] 1 2

> mean(c(1,2)) #mean function
[1] 1.5

> seq(1,4) #create a sequence of values
[1] 1 2 3 4
Understanding classes of R objects is necessary for analysis.

An object is any variable of interest that you want to work with.

The class defines the type of information the object contains.

```r
> class(1)
[1] "numeric"
> class("1")
[1] "character"
```

'Factors' are also common, define categorical variables.
Understanding classes of R objects is necessary for analysis

An object is any variable of interest that you want to work with

The class defines the type of information the object contains

Most common are ‘numeric’ or ‘character’ classes

```r
> class(1)
[1] "numeric"
> class("1")
[1] "character"
```

‘Factors’ are also common, define categorical variables
Understanding classes of R objects is necessary for analysis.

The classes of an object defines a protocol for evaluating or organizing variables.

For example, we cannot add two objects with different classes:

```r
> '1' + 1
Error in "1" + 1 : non-numeric argument to binary operator
```
Objects (and their classes) can be stored in the computer’s memory in different ways - aka the workspace for your R session

Most common structures are ‘vectors’ and ‘data.frames’
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Vectors are a collection of objects of the same class (e.g., a column in a table), whereas a data frame is analogous to a table with rows and columns (e.g., collection of vectors)
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Vectors are a collection of objects of the same class (e.g., a column in a table), whereas a data frame is analogous to a table with rows and columns (e.g., collection of vectors)

```r
> a<-c(1,2)
> a
[1] 1 2
> b<-c("a","b")
> b
[1] "a" "b"
```
basics

Objects (and their classes) can be stored in the computer’s memory in different ways - aka the workspace for your R session

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Vectors are a collection of objects of the same class (e.g., a column in a table), whereas a data frame is analogous to a table with rows and columns (e.g., collection of vectors)

```r
> a<-c(1,2)
> a
[1] 1 2
> b<-c("a","b")
> b
[1] "a" "b"
> c<-data.frame(a,b)
> c
   a b
1 1 a
2 2 b
```
How are data imported into R?

R needs to know where the data are located on your computer:

```r
> setwd("C:/projects/my_data/")
```

This establishes a ‘working directory’ for data import/export
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```

This establishes a ‘working directory’ for data import/export

R can import almost any type of data but ‘spreadsheet’ or text-based files are most common
How are data imported into R?

R can import Excel data using the RODBC package, but this is not simple
How are data imported into R?

R can import Excel data using the RODBC package, but this is not simple.

The easiest approach is to format data in Excel then export to a .csv or .txt file.
basics

How are data imported into R?

Use the read.table or read.csv functions to import the data, must be in your working directory
How are data imported into R?

Use the `read.table` or `read.csv` functions to import the data, must be in your working directory

```r
> dat <- read.csv("my_data.csv", header=T)
> dat

    Group Value Type
   1     a   3  n
   2     b   6  n
   3     a   4  n
   4     b   1  l
   5     a   6  l
   6     b   2  l
```
How are data imported into R?

Use the read.table or read.csv functions to import the data, must be in your working directory

```r
> dat<-read.table("my_data.csv",sep=',',header=T)
> dat

  Group Value Type
  1   a   3   n
  2   b   6   n
  3   a   4   n
  4   b   1   l
  5   a   6   l
  6   b   2   l
```
Imported data can be viewed several ways, view the whole object or parts.

Rows or columns can be obtained by indexing with brackets separated by a comma: `data[row,column]`
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```r
> dat

<table>
<thead>
<tr>
<th>Group</th>
<th>Value</th>
<th>Value</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>a</td>
<td>3</td>
<td>n</td>
</tr>
<tr>
<td>2</td>
<td>b</td>
<td>6</td>
<td>n</td>
</tr>
<tr>
<td>3</td>
<td>a</td>
<td>4</td>
<td>n</td>
</tr>
<tr>
<td>4</td>
<td>b</td>
<td>1</td>
<td>l</td>
</tr>
<tr>
<td>5</td>
<td>a</td>
<td>6</td>
<td>l</td>
</tr>
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<td>l</td>
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</tbody>
</table>
```
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```
> dat
  Group Value Type
 1   a   3  n
 2   b   6  n
 3   a   4  n
 4   b   1  l
 5   a   6  l
 6   b   2  l

> dat[,2]  #column 2
[1] 3 6 4 1 6 2

> dat[4,1] #row 4, column 1
[1] b
Levels: a b
```
Imported data can be viewed several ways, view the whole object or parts

Access using column names or the attach function

```r
> dat$Value
[1] 3 6 4 1 6 2

> dat[, 'Value']
[1] 3 6 4 1 6 2

> attach(dat)

> Value
[1] 3 6 4 1 6 2
```
Imported data can be viewed several ways, view the whole object or parts

Access using column names or the attach function

```r
> dat$Value
[1] 3 6 4 1 6 2

> dat[, 'Value']
[1] 3 6 4 1 6 2

Vectors can be indexed similarly as data frames

> Value[2]
[1] 6
```
basics

Where to go for help?

- A user-friendly intro to R
basics

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basics

Where to go for help?

- A user-friendly *intro to R*
- R cheatsheet
Where to go for help?

- A user-friendly intro to R
- R cheatsheet
- Google is your friend
Where to go for help?

- A user-friendly *intro to R*
- *R cheatsheet*
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- Help files for each function using `?function` - may or may not be helpful
Where to go for help?

- A user-friendly intro to R
- R cheatsheet
- Google is your friend
- Help files for each function using ‘?function’ - may or may not be helpful
- An intro to R - very detailed
- Ask us!