An Introduction to R

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An Introduction to R

1. Getting Started
2. R as a simple calculator
3. Simple Statistical Operations
   - Entering Data as a Vector
   - Basic Descriptive Statistics
   - Listwise Transformations
   - Statistical Distribution Functions
   - Basic Statistical Graphics
4. Defining Your Own Functions

Running R

Starting the Program

- After installing the program, you start R by clicking on the desktop blue R icon, or by using the Start menu
- You will need to install the arm package.

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Simple Calculations in R

Entering Simple Commands

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- When you see the > character, you are being prompted for input
- To enter a command, type it in and press the <Enter> key, and you will see the output
- Here is a simple example:

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Arithmetic Syntax

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- In R, $+$ and $-$ mean addition and subtraction, respectively
- $*$ and $/$ mean multiplication and division
- *Remember*, you must enter the $*$
- Exponentiation is indicated with a carat, i.e., ^

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Simple Calculations in R

Arithmetic Syntax

Example (Very Simple Calculations)

Here are some simple examples:

```
> 3*8

[1] 24

> 4*(2-1)

[1] 4

> 2^4

[1] 16

> 3^(2+1)

[1] 27
```

Simple Calculations in R

Arithmetic Syntax

Example (Slightly More Complicated Calculations)

Here are some slightly more complicated examples

```
> sqrt(5*(14-2)/11)

[1] 2.335497

> ((3+6)/11)^2

[1] 0.6694215
```

Entering Data as a Vector

Entering Data as a Vector

- Suppose we wished to analyze the list of numbers 1,2,3,4,5
- Entering that in R is simple, using the concatenation function `c()`
- In the example below, we enter the vector of numbers 1,2,3,4,5 and assign it to the variable `x`

Entering Data as a Vector

Example (Assigning a List to a Variable)

```
> x ← c(1,2,3,4,5)
> x

[1] 1 2 3 4 5
```

Basic Descriptive Statistics

Example (Some Basic Statistics)

Once we have our numbers in a variable, it is easy to compute basic summary statistics

```
> x ← c(1,2,3,4,5)
> mean(x)

[1] 3

> var(x)

[1] 2.5

> sd(x)

[1] 1.581139
```

Listwise Transformations

Example (Listwise Transformations)

It is ridiculously simple to do simple listwise transformations in R. Just write the formula. Below we verify something from Psychology 310, i.e., that if $y = 2x + 5$, then $\overline{y} = 2\overline{x} + 5$.

```
> x ← c(1,2,3,4,5)
> y ← 2*x + 5
> y

[1]  7  9 11 13 15

> mean(y)

[1] 11

> 2*mean(x)+5

[1] 11
```

Statistical Distribution Functions

pdfs and cdfs

Statistical Distribution Functions

- R has a wide range of capabilities for displaying and forming calculations involving distribution functions
- Recall that, for distribution functions, there are several quantities we can calculate
- For each distribution, there is the *probability distribution function* (pdf) and the *cumulative distribution function* (cdf)

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Statistical Distribution Functions

- The cdf, denoted $F(x)$, is the probability that an observation taken at random from the distribution is less than or equal to x
- The term *pdf* can mean two different things, depending on whether the distribution is continuous or discrete:
  - For continuous distributions, it is denoted $f(x)$ and is the probability density
  - For discrete distributions, it is denoted $p(x)$ and refers to the probability that an observation taken at random from the distribution is equal to x (for discrete distributions)
- We shall illustrate each using the normal distribution as an example

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Statistical Distribution Functions

The Normal Distribution

The Normal pdf

- Statistical distribution functions in R are called with a common set of conventions
- A function name is of the form [prefix][distribution name]
- The prefixes are a fixture in R, which makes things easier

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Statistical Distribution Functions

The Normal Distribution cdf

The Normal cdf

- Consider the normal distribution cdf
- All cdfs use the prefix `p` followed by the distribution name
- To call the normal distribution cdf, you use the function `pnorm()`

Statistical Distribution Functions

The Normal Distribution cdf

The Normal Distribution cdf

- The function `pnorm()` illustrates some neat features of R functions and their specification
- If we look up the guide to calling the function, it says that the function call is of the form `pnorm(x,mean=0,sd=1)`
- When an argument name is given with an `=` sign, as in `mean = 0`, it means there is a *default value* for the argument
- If you leave out default arguments, the default values are assumed

Statistical Distribution Functions

The Normal Distribution cdf

Example (The Normal Distribution cdf)

```
> pnorm(1, mean=0, sd=1)
[1] 0.8413447
> pnorm(1)
[1] 0.8413447
> pnorm(1,0,1)
[1] 0.8413447
> pnorm(115,100,15)
[1] 0.8413447
```

Statistical Distribution Functions

The Normal Distribution pdf

The Normal Distribution pdf

- pdfs use the prefix `d`
- So the normal pdf is called with the function of the form `dnorm(x,mean=0,sd=1)`

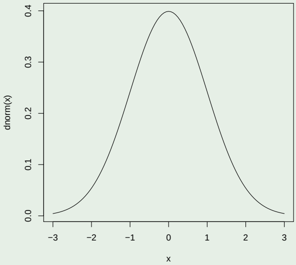
Statistical Distribution Functions

The Normal Distribution pdf

Example (Plotting the Normal Distribution)

You can plot the normal curve density function using the `curve()` function, which is used in general to plot curves. The following call plots the normal density over the interval $-3 \leq x \leq 3$.

```
> curve(dnorm(x),-3,3)
```



Statistical Distribution Functions

Quantiles

Quantiles

- A very valuable function for any distribution is the ability to compute percentile points
- R implements this in its quantile function
- Quantiles are indicated with the prefix `q` in front of the distribution name
- For example, a normal distribution quantile uses the function `qnorm(p,mean=0,sd=1)`

Statistical Distribution Functions

Quantiles

Example (Normal Distribution Quantiles)

Computing the 90th percentile for a standard normal distribution:

```
> qnorm(.90)
```

```
[1] 1.281552
```

Computing the 75th percentile for a normal distribution with a mean of 100 and a standard deviation of 15:

```
> qnorm(.90,100,15)
```

```
[1] 119.2233
```

Statistical Distribution Functions

Random Number Generation

Example (Random Number Generation)

It is very useful to be able to simulate sampling from a known distribution. In the following example, we create two simulated samples, each of size 100. For reproducibility, we set the random number seed.

```
> set.seed(12345)
> x ← rnorm(100,80,12)
> y ← rnorm(100, 72, 8)
```

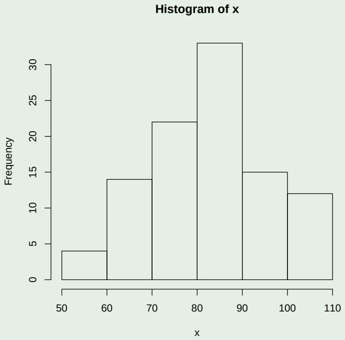
Basic Statistical Graphs

The History

Example (The Histogram)

Here is a histogram of the x data from the preceding slide:

```
> hist(x)
```



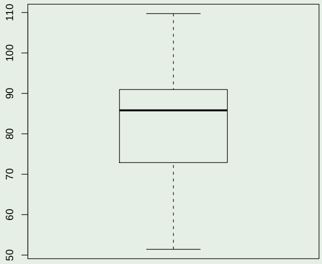
Basic Statistical Graphs

The Boxplot

Example (The Boxplot)

Here is a boxplot of the x data from the preceding slide:

```
> boxplot(x)
```



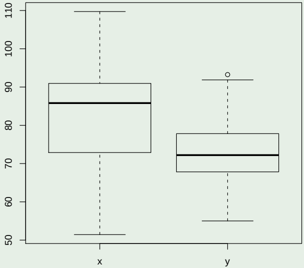
Basic Statistical Graphs

Boxplots Side-by-Side

Example (Boxplots Side-by-Side)

Comparing distributions is greatly facilitated by having boxplots side-by-side.

```
> boxplot(x,y,names = c('x','y'))
```



Defining Functions in R

As a statistical analysis environment, R is readily extended by user-defined functions. To define a function, you take a name, tell R that this object is a function, and list its arguments. You then define what the function does inside a set of braces. Here is a very simple example:

Example (A Deviation Score Function)

```
> deviation.score ← function(x)
+ {
+ return( x-mean(x) )
+ }
> w ← c(3,4,3,2,8)
> deviation.score(w)

[1] -1  0 -1 -2  4
```

Combining Functions

Example (Combining Functions)

We can use the `deviation.score` function we just defined as a building block in another function For example, here is a simple variance calculator. Note that it uses the `length` function and the `deviation.score` function.

```
> variance ← function(x)
+ { return( sum(deviation.score(x)^2)
+              / ( length(x)-1 ) ) }
> deviation.score(w)

[1] -1  0 -1 -2  4

> deviation.score(w)^2

[1]  1  0  1  4 16

> variance(w)

[1] 5.5
```