

Analytics of Business Intelligence

Introduction to the Fall 2019 Semester

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Bio - Dr. Wajahat Gilani



Academics (All Rutgers)

- BS Computer Science and BA Economics
- Master in Quantitative Finance (before the program split)
- Ph.D. in Optimal Investing in Illiquid and Incomplete Markets

Experience

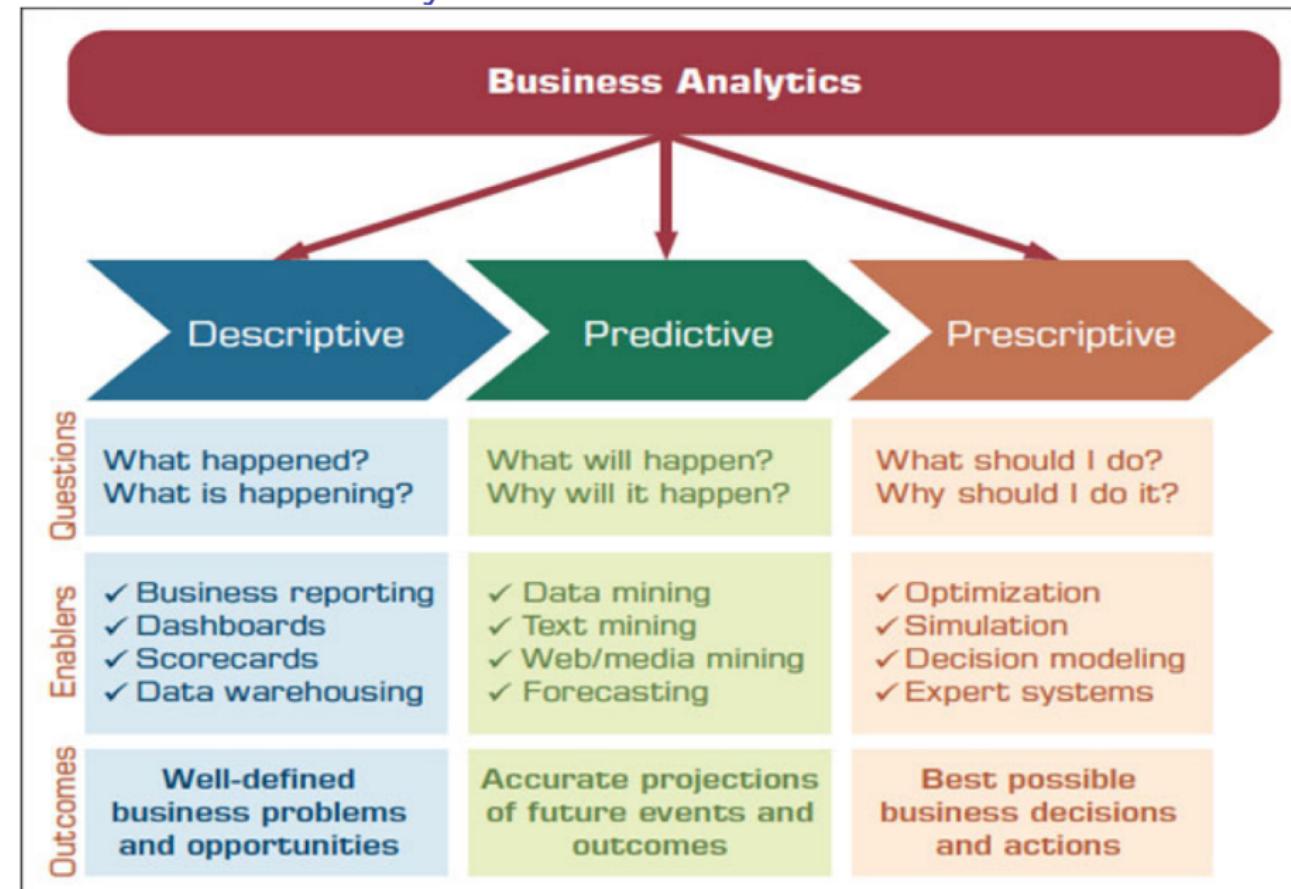
- Merrill Lynch Investment Managers (BlackRock) - Front Office Application developer/Junior Quantitative Analyst
- JP Morgan Chase - Jumbo loans quant
- Libertas Partners - Desk Quant (ABS/CDO) "The Big Short"
- Libertas Partners - Desk Quant (ABS/CDO) "The Big Short"
- Citigroup - FX Derivative Quant
- Quant Consultant for Hedge Funds
- Private Investment Fund

What is Data Science?

Analytics Overview

- Analytics...a relatively new term/buzz-word
- Analytics...the process of developing actionable decisions or recommendations for actions based on insights generated from historical data
- According to the Institute for Operations Research and Management Science (INFORMS)
 - Analytics represents the combination of computer technology, management science techniques, and statistics to solve real problems.

4 Domains of Analytics?



What is Prescriptive Analytics

The relatively new field of prescriptive analytics allows users to “prescribe” a number of different possible actions to and guide them towards a solution. In a nut-shell, these analytics are all about providing advice. Prescriptive analytics attempt to quantify the effect of future decisions in order to advise on possible outcomes before the decisions are actually made. At their best, prescriptive analytics predicts not only what will happen, but also why it will happen providing recommendations regarding actions that will take advantage of the predictions.

These analytics go beyond descriptive and predictive analytics by recommending one or more possible courses of action. Essentially they predict multiple futures and allow companies to assess a number of possible outcomes based upon their actions. Prescriptive analytics use a combination of techniques and tools such as business rules, algorithms, machine learning and computational modelling procedures. These techniques are applied against input from many different data sets including historical and transactional data, real-time data feeds, and big data.

What is Prescriptive Analytics (Cont'd)

Prescriptive analytics are relatively complex to administer, and most companies are not yet using them in their daily course of business. When implemented correctly, they can have a large impact on how businesses make decisions, and on the company's bottom line. Larger companies are successfully using prescriptive analytics to optimize production, scheduling and inventory in the supply chain to make sure that are delivering the right products at the right time and optimizing the customer experience.

Download R and RStudio

<https://www.r-project.org>



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The R Project for Statistical Computing

Getting Started

R is a free software environment for statistical computing and graphics. It compiles and runs on a wide variety of UNIX platforms, Windows and MacOS. To [download R](#), please choose your preferred [CRAN mirror](#).

If you have questions about R like how to download and install the software, or what the license terms are, please read our [answers to frequently asked questions](#) before you send an email.

News

- [R version 3.6.1 \(Action of the Toes\)](#) has been released on 2019-07-05.
- useR! 2020 will take place in St. Louis, Missouri, USA.
- [R version 3.5.3 \(Great Truth\)](#) has been released on 2019-03-11.
- The R Foundation Conference Committee has released a [call for proposals](#) to host useR! 2020 in North America.
- You can now support the R Foundation with a renewable subscription as a [supporting member](#)

Download R and RStudio

CRAN Mirrors

The Comprehensive R Archive Network is available at the following URLs, please choose a location close to you. Some statistics on the status of the mirrors can be found here: [main page](#), [windows release](#), [windows old release](#).

If you want to host a new mirror at your institution, please have a look at the [CRAN Mirror HOWTO](#).

0-Cloud

<https://cloud.r-project.org/>

Automatic redirection to servers worldwide, currently sponsored by
Rstudio

Algeria

<https://cran.usthb.dz/>

University of Science and Technology Houari Boumediene

Argentina

<http://mirror.fcaglp.unlp.edu.ar/CRAN/>

Universidad Nacional de La Plata

Australia

<https://cran.csiro.au/>

CSIRO

<https://mirror.aarnet.edu.au/pub/CRAN/>

AARNET

<https://cran.ms.unimelb.edu.au/>

School of Mathematics and Statistics, University of Melbourne

<https://cran.curtin.edu.au/>

Curtin University of Technology

Austria

<https://cran.wu.ac.at/>

Wirtschaftsuniversität Wien

Belgium

<https://www.freestatistics.org/cran/>

Patrick Wessa

<https://lib.ugent.be/CRAN/>

Ghent University Library

Brazil

<https://cran-r.c3sl.ufpr.br/>

Universidade Federal do Paraná

<https://cran.fiocruz.br/>

Oswaldo Cruz Foundation, Rio de Janeiro

<https://vps.fmvz.usp.br/CRAN/>

University of São Paulo, São Paulo

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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!

- The latest release (2019-07-05, Action of the Toes) [R-3.6.1.tar.gz](#), read [what's new](#) in the latest version.
- 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](#)

Download R and RStudio (MAC)



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R for Mac OS X

This directory contains binaries for a base distribution and packages to run on Mac OS X (release 10.6 and above). Mac OS 8.6 to 9.2 (and Mac OS X 10.1) are no longer supported but you can find the last supported release of R for these systems (which is R 1.7.1) [here](#). Releases for old Mac OS X systems (through Mac OS X 10.5) and PowerPC Macs can be found in the [old](#) directory.

Note: CRAN does not have Mac OS X systems and cannot check these binaries for viruses. Although we take precautions when assembling binaries, please use the normal precautions with downloaded executables.

As of 2016/03/01 package binaries for R versions older than 2.12.0 are only available from the [CRAN archive](#) so users of such versions should adjust the CRAN mirror setting accordingly.

R 3.6.1 "Action of the Toes" released on 2019/07/05

Important: since R 3.4.0 release we are now providing binaries for OS X 10.11 (El Capitan) and higher using non-Apple toolkit to provide support for OpenMP and C++17 standard features. To compile packages you may have to download tools from the [tools](#) directory and read the corresponding note below.

Please check the MD5 checksum of the downloaded image to ensure that it has not been tampered with or corrupted during the mirroring process. For example type

`md5 R-3.6.1.pkg`

in the *Terminal* application to print the MD5 checksum for the R-3.6.1.pkg image. On Mac OS X 10.7 and later you can also validate the signature using

`pkgutil --check-signature R-3.6.1.pkg`

Latest release:

R-3.6.1.pkg

MD5-hash: 279e6662103dfe6a625b4573143cb995
SHA1-
hash: 4e932f8e5013870d2a9179b54eae277f41657b0
(ca. 76MB)

R 3.6.1 binary for OS X 10.11 (El Capitan) and higher, signed package.

Contains R 3.6.1 framework, R.app GUI 1.70 in 64-bit for Intel Macs, Tcl/Tk 8.6.6 X11 libraries and Texinfo 5.2. The latter two components are optional and can be omitted when choosing "custom install", they are only

Download R and RStudio (Windows)



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R for Windows

Subdirectories:

base	Binaries for base distribution. This is what you want to install R for the first time .
contrib	Binaries of contributed CRAN packages (for R >= 2.13.x; managed by Uwe Ligges). There is also information on third party software available for CRAN Windows services and corresponding environment and make variables.
old contrib	Binaries of contributed CRAN packages for outdated versions of R (for R < 2.13.x; managed by Uwe Ligges).
Rtools	Tools to build R and R packages. This is what you want to build your own packages on Windows, or to build R itself.

Please do not submit binaries to CRAN. Package developers might want to contact Uwe Ligges directly in case of questions / suggestions related to Windows binaries.

You may also want to read the [R FAQ](#) and [R for Windows FAQ](#).

Note: CRAN does some checks on these binaries for viruses, but cannot give guarantees. Use the normal precautions with downloaded executables.

Download R and RStudio

<https://www.rstudio.com>

The screenshot shows the RStudio homepage with a dark blue hexagonal background pattern. On the left, the RStudio logo is displayed. At the top right, there are navigation links: Products, Resources, Pricing, About Us, Blogs, and a search icon. The main title "RStudio" is prominently displayed in large white letters. Below it, the tagline "Open source and enterprise-ready professional software for R" is visible. To the right, there are four rectangular call-to-action boxes with rounded corners, each containing a link: "Download RStudio", "Discover Shiny", "Discover RStudio Team", and "Discover RStudio Server Pro Standard and Enterprise". A small "..." icon is located at the bottom center of the page.

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Open source and enterprise-ready professional software for R

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...

Introducing RStudio Team



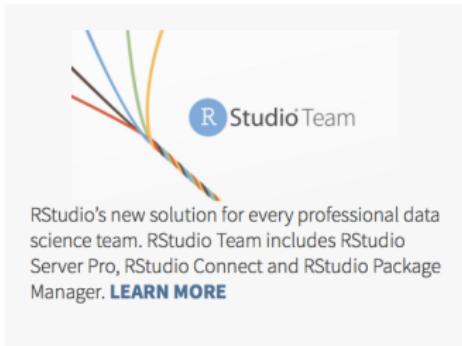
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Choose Your Version of RStudio

RStudio is a set of integrated tools designed to help you be more productive with R. It includes a console, syntax-highlighting editor that supports direct code execution, and a variety of robust tools for plotting, viewing history, debugging and managing your workspace. [Learn More](#) about RStudio features.



RStudio's new solution for every professional data science team. RStudio Team includes RStudio Server Pro, RStudio Connect and RStudio Package Manager. [LEARN MORE](#)

RStudio Desktop	RStudio Desktop	RStudio Server	RStudio Server Pro
Open Source License	Commercial License	Open Source License	Commercial License
FREE	\$995 per year	FREE	\$4,975 per year (5 Named Users)
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RStudio Desktop 1.2.1335 — Release Notes

RStudio requires R 3.0.1+. If you don't already have R, download it [here](#).

Linux users may need to import RStudio's public code-signing key prior to installation, depending on the operating system's security policy.

RStudio 1.2 requires a 64-bit operating system, and works exclusively with the 64 bit version of R. If you are on a 32 bit system or need the 32 bit version of R, you can use an [older version of RStudio](#).

Installers for Supported Platforms

Installers	Size	Date	MD5
RStudio 1.2.1335 - Windows 7+ (64-bit)	126.9 MB	2019-04-08	d0e2470f1f8ef4cd35a669aa323a2136
RStudio 1.2.1335 - macOS 10.12+ (64-bit)	121.1 MB	2019-04-08	6c570b0e2144583f7c48c284ce299eef
RStudio 1.2.1335 - Ubuntu 14/Debian 8 (64-bit)	92.2 MB	2019-04-08	c1b07d0511469abfe582919b183eee83
RStudio 1.2.1335 - Ubuntu 16 (64-bit)	99.3 MB	2019-04-08	c142d69c210257fb10d18c045fff13c7
RStudio 1.2.1335 - Ubuntu 18/Debian 10 (64-bit)	100.4 MB	2019-04-08	71a8d1990c0d97939804b46cfb0aea75
RStudio 1.2.1335 - Fedora 19/RedHat 7 (64-bit)	114.1 MB	2019-04-08	296b6ef88969a91297fab6545f256a7a
RStudio 1.2.1335 - Debian 9 (64-bit)	100.6 MB	2019-04-08	1e32d4d6f6e216f086a81ca82ef65a91
RStudio 1.2.1335 - OpenSUSE 15 (64-bit)	101.6 MB	2019-04-08	2795a63c7efd8e2aa2dae86ba09a81e5
RStudio 1.2.1335 - SLES/OpenSUSE 12 (64-bit)	94.4 MB	2019-04-08	c65424b06ef6737279d982db9eefcae1

Solve An Equation in R

The screenshot shows the RStudio interface. The top menu bar includes 'File', 'Edit', 'Source', 'View', 'Tools', 'Help', 'Go to file/function', and 'Addins'. The main workspace shows the code:

```
Untitled5* x
Source on Save | Run | Source |
```

```
1 11000*(1.1)^4 + 11000*(1.1)^3 + 11000*(1.1)^2 + 11000*(1.1)^1
2
```

The status bar at the bottom left indicates '2:1 (Top Level)'. The bottom panel shows the 'Console' tab active, displaying the command and its result:

```
R Script
```

```
Console Terminal x
~/Documents/Investment in R/priceobjects/
> 11000*(1.1)^4 + 11000*(1.1)^3 + 11000*(1.1)^2 + 11000*(1.1)^1
[1] 56156.1
>
```

1 $11000 * (1.1)^4 + 11000 * (1.1)^3 + 11000 * (1.1)^2 + 11000 * (1.1)^1$

Solve it in R: Data Container

The screenshot shows the RStudio interface with the following components:

- Code Editor:** An untitled script named "Untitled5.R" containing the following R code:

```
1 x=.1
2 11000*(1+x)^4 + 11000*(1+x)^3 + 11000*(1+x)^2 + 11000*(1+x)^1
```
- Console:** Displays the output of the executed code:

```
> 11000*(1.1)^4 + 11000*(1.1)^3 + 11000*(1.1)^2 + 11000*(1.1)^1
[1] 56156.1
> x=.1
> 11000*(1+x)^4 + 11000*(1+x)^3 + 11000*(1+x)^2 + 11000*(1+x)^1
[1] 56156.1
>
```
- Environment View:** Shows the variable "x" with the value "0.1".
- Packages View:** Shows the "System Library" with a list of installed packages and their details. Some packages are marked with a blue circle icon.

Vectors

```
1 x = .1  
2  
3 11000*(1+x)^4 + 11000*(1+x)^3 + 11000*(1+x)^2 + 11000*  
   (1+x)^1
```

Answer: 56156.1

.1

x

"x" is a variable name, you can name variables anything you want, but remember they are case-sensitive. The variable "x" is a vector of size 1, and contains the value .1. If you run any line with just the variable name, the console will display the value(s).

```
1 x
```

> x

[1]0.1

Container vs Data



The book is 0.1, the shelf is x , its a data container. Meaning the vector holds data for you to use.

```
1 x [1]
```

Console:

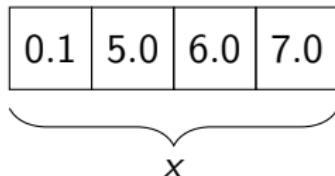
```
> x
```

```
[1]0.1
```

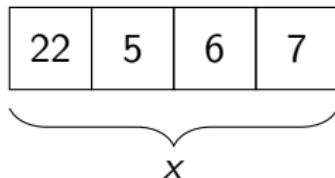
Changing a Vector

Append numbers 5, 6 and 7 to vector "x".

- 1 x [2]=5
- 2 x [3]=6
- 3 x [4]=7



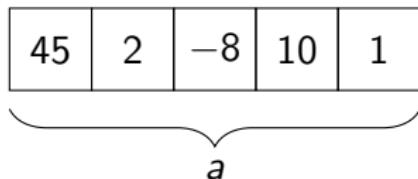
- 1 x [1]=22



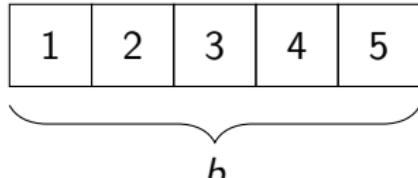
Creating Vectors

Some basic ways to create vectors.

```
1 a=c(45,2,-8,10,1)
```



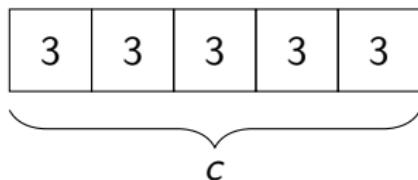
```
1 b=1:5
```



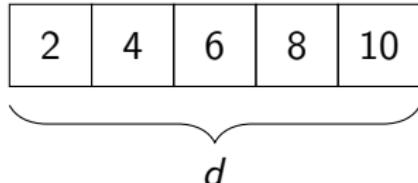
Creating Vectors (Continued)

Some basic ways to create vectors.

```
1 c=rep(3,5)
```



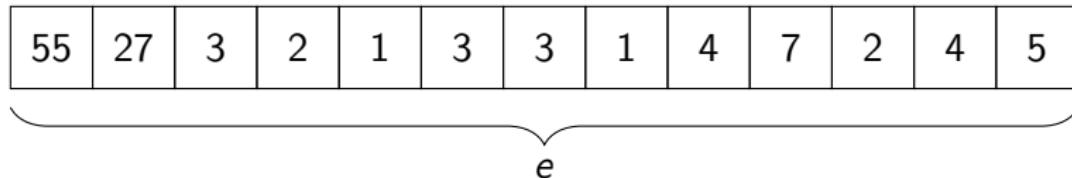
```
1 d=seq(2,10,2)
```



Creating Vectors (The C function)

The c-function you will see a lot and is very flexible.

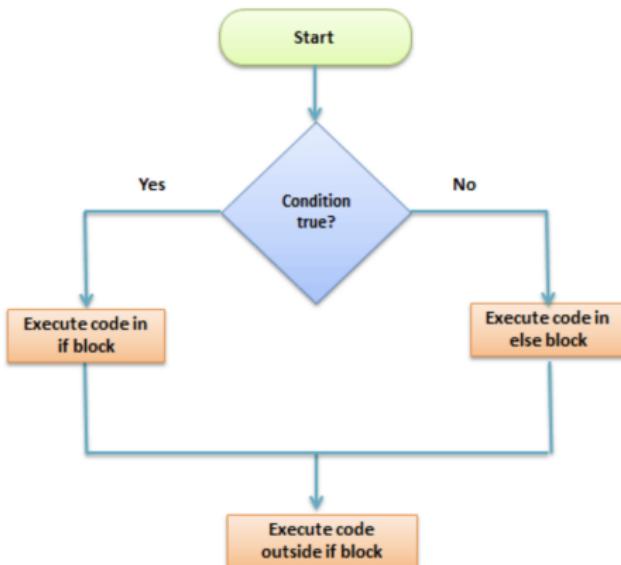
```
1 e=c(55,27,3:1,rep(3,2),seq(1,7,3),c(2,4,5))
```



```
1 f=c(55,
```

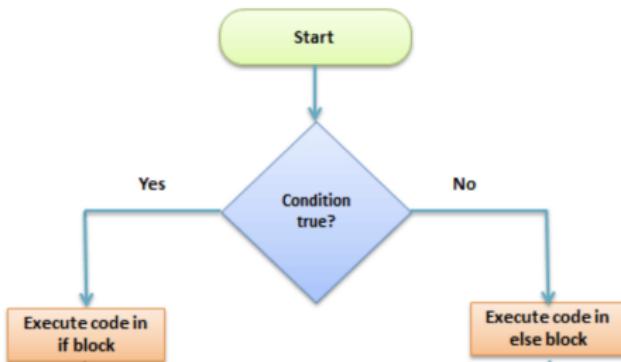
For Loop - If/else statements

```
1 if (condition) {  
2   Expr1  
3 } else {  
4   Expr2  
5 }
```



For Loop - If/else statements

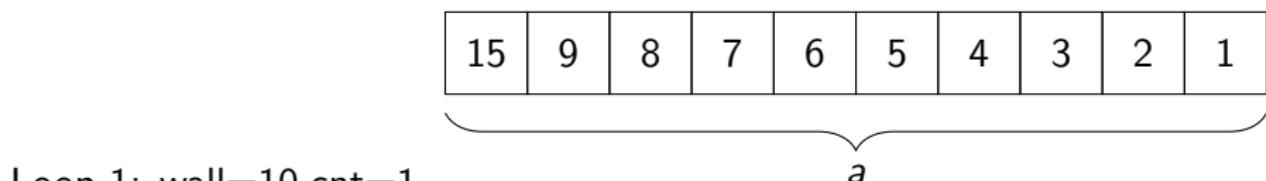
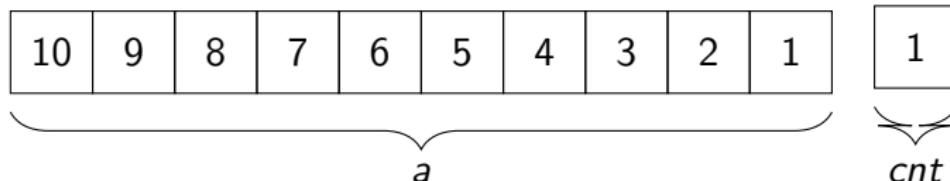
```
1 quantity = 25
2
3 if (quantity > 20)
4 {
5     print('You sold a lot!')
6 }
7 else
8 {
9     print('Not enough for today')
0 }
```



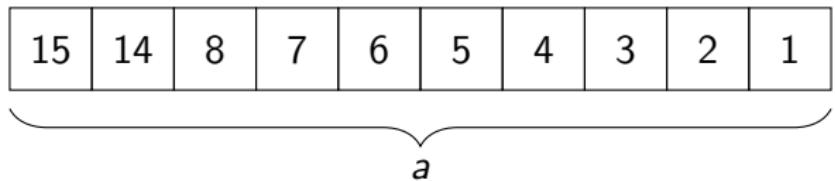
For Loop - If/else statements

```
1 a = 10:1
2 cnt=1
3
4 for(wall in a)
5 {
6     a[cnt]=wall+5
7     cnt = cnt+1
8 }
9
0 NROW(a)
1 length(a)
2
3 v=1:NROW(a)
4
5 for(joey in v)
6 {
7     a[joey]=a[joey]+5
8 }
```

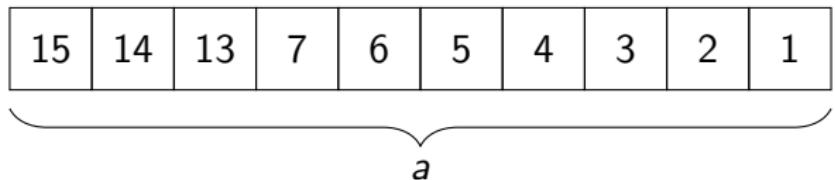
For Loop - If/else statements



Loop 1: wall=10, cnt=1

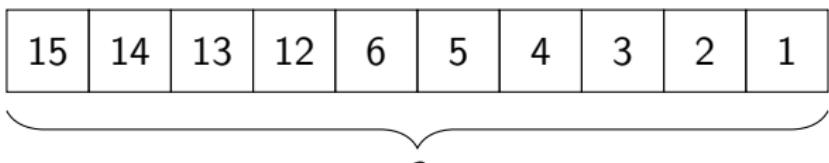


Loop 2: wall=9, cnt=2

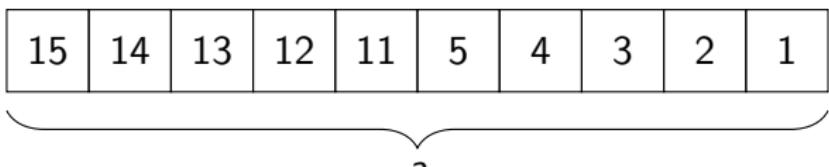


Loop 3: wall=8, cnt=3

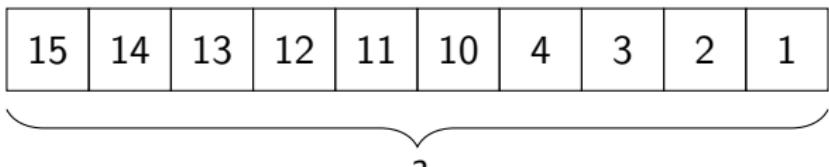
For Loop - If/else statements



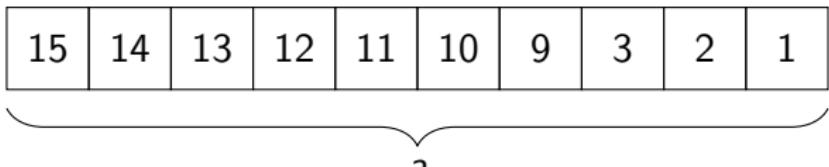
Loop 4: wall=7, cnt=4



Loop 5: wall=6, cnt=5



Loop 6: wall=5, cnt=6



Loop 7: wall=4, cnt=7

For Loop - If/else statements

```
1 b=1:5
2
3 for(janice in 1:NROW(b))
4 {
5   if(b[janice]<3)
6   {
7     b[janice]=b[janice]+5
8   }
9   else
10  {
11    b[janice]=b[janice]-5
12  }
13 }
```

For Loop - If/else statements

```
1 a=10:1
2 #10,9,8,7,6,5,4,3,2,1
3
4 a=a+5
5 #15,14,13,12,11,10,9,8,7,6
6
7 b=1:5
8 b<3
9 #TRUE, TRUE, FALSE, FALSE, FALSE
0
1 b[1:3] #1 2 3
2 b[c(1,4)] # 1 4
3
4 b[b<3]=b[b<3]+5
5 #[6,7]=[1,2]+5
6 b[b>=3]=b[b>=3]-5
7 #[−2,−1,0]=[3,4,5]-5
8 b[b>0]=b+5
9 #6 7 -2 -1 0
```

User-Defined Functions Example

Example, you want to make a simple function that multiplies any inputted number by 5:

```
1 exmp = function(x)
2 {
3     return(5*x)
4 }
5
6 exmp(10)
7 exmp(50)
8 exmp(100)
```

Solution:

50

250

500

User-Defined Functions Advanced Example

What is A(4,B(2,A(1,1)))?

```
1 A = function(x,y)
2 {
3     if (x+y>7)
4     {
5         tot = x+y
6     }
7     else
8     {
9         tot = x*y
10    }
11    return(tot)
12 }
13
14 B = function(a,b)
15 {
16     tot=a*b + 10
17     return(tot)
18 }
```

List Container

The data container *res* is a List. A list is basically a data container that holds other data containers. For example:

```
1 l1=list(a=5:1 , b=c(1,3,5) , c=5)
```

l1 contains:

