Modeling in Education, and Social Sciences Using R

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Introduction to Simple Models

This chapter of the notebook corresponds to chapters 1 and 2 of Judd et al. (2017).

Chapter 2

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This chapter of the notebook corresponds to chapters 3 and 4 of Judd et al. (2017).

Chapter 3

Simple Regression

This chapter of the notebook corresponds to chapter 5 of Judd et al. (2017).

Chapter 4

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This chapter of the notebook corresponds to Chapter 13 of Judd et al. (2017).

Chapter 5

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This chapter of the notebook corresponds to chapter 6 of Judd et al. (2017).

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This chapter of the notebook corresponds to chapter 7 of Judd et al. (2017).

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This chapter of the notebook corresponds to chapter 8 of Judd et al. (2017).

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This chapter of the notebook corresponds to chapter 9 of Judd et al. (2017).

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This chapter of the notebook corresponds to chapter 10 of Judd et al. (2017).

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This chapter of the notebook corresponds to chapter 11 of Judd et al. (2017).

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This chapter of the notebook corresponds to chapter 12 of Judd et al. (2017).

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This chapter of the notebook corresponds to chapter 14 of Judd et al. (2017).

Appendix A

Appendix A: R as a Statistical Programming Language

A.1 Overview

```
library(knitr)
```

- Why use Statistical Programming Languages?

Computers and Programs

- Fixed program computer
  - programs are "hard-wired" into computer
  - calculator, stopwatch
- Stored program computer
  - machine stores and executes instructions
  - most modern computers, your phone, etc.

Statistical Programs versus Statistical Programming Language

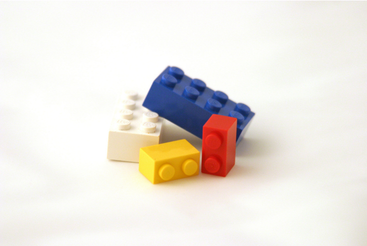
- Statistical Programs
  - fixed menus
  - limited procedures (at least in the menus)
  - leads to compartmentalizing models (e.g. ANOVA, regression, GLM)
- Statistical Programming Languages (SPLs)
  - Turing complete: if you can create an algorithm you can program it
  - Very flexible
  - Integration of models: One model to rule them all!

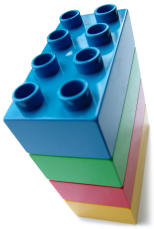
Everythin

A.2 Elements of Statistical Programming

A.2.1 Basic Elements of a Good SPL

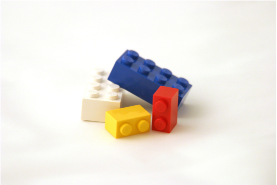
1. a rich set of **primitive expressions**
2. mechanisms for **combining expressions** into more complex expressions
3. means of **abstraction**, which allow for naming and manipulating compound objects





A.3 Expressions

A.4 Primitive Expressions



- Everything in R is an object
- Primitive objects are the simplest elements of a programming language, and include:
  - *primitive data*
  - *primitive functions*
- They can be thought of as the basic building blocks for everything else in the language.
- An **expression** is an input that the programming language can evaluate, and consists of function and data objects.

A.5 Primitive Data Types:

Data objects are the primary means of storing information in R. R has a few basic *data types*:

- **Numeric** -
  - `numeric`
    - `int` - integers (`1,2`)
    - `num` - real number (`1.2, -3.1, 200.0`)
- **character** or **string** -
  - `character`
    - `"Hello world!"`, `"Ten"`, `'Cat'`
    - `"This is a sentence, which is a string"`
    - `"10"` (in single or double quotes, as long as they match)
- **Boolean** or **Logical**
  - `logical`
    - `TRUE` or `FALSE` (use operators such as *or*, *and* and *not*).
    - They will evaluate to numbers where `FALSE` evaluates to zero, and `TRUE` evaluates to one.
    - For example. if you enter `TRUE + 1` you will get `2` in return.

```
mode(TRUE)
```

```
## [1] "logical"
```

```
TRUE + 1
```

```
## [1] 2
```

A.6 Primitive Functions

R uses functions to do all computations.

A.6.1 Operators

- Arithmetic Operators
  - +, -, *, /, ^
- Comparison (also called Boolean, Logical or Predicate) Operators
  - `<, >, ==, <=, >=, !=`
  - less than, greater than, equal to, less than or equal to, greater than or equal to, not equal to
  - return `TRUE` or `FALSE`
- Logical Operator
  - `&`, `|` ,`!`
  - also return `TRUE` or `FALSE`
- Other functions
  - `mode()`
  - `length()`
  - `sum()`
  - `sqrt()`
  - `log()`
  - `exp()`
- Assignment operators (assignment will be discussed below)
  - **`<-` preferred assignment operator - always use this one**
  - `=` this will also work, but can be confusing (note different from `==`, the comparison operator)
  - `->` is also an assignment operator, but we will not use it.

A.7 Programming Languages are Not Forgiving

A.7.1 Syntactically valid expressions

Expressions must be syntactically valid.

- syntax (form)
  - English: “cat dog boy” - not syntactically valid
  - English: “cat hugs boy” - syntactically valid

- programming language:
    - “hi” 5 - not syntactically valid
    - 3.2*5 - syntactically valid

A.7.2 Semantically valid expressions

- semantics - (meaning)
    - English: “I are hungry” - syntactically valid but semantic error
    - programming language:
        - 3 + “hi” - semantic error (you can’t use addition on character strings)
- Chomsky: “colorless green ideas sleep furiously”

This statement is syntactically valid, but does not make sense, so makes a semantic error.

A.8 Assignment

We will often want to save data in a variable. We can do that with **assignment**, which utilizes an assignment operator.

```
x <- 2
```

```
x
```

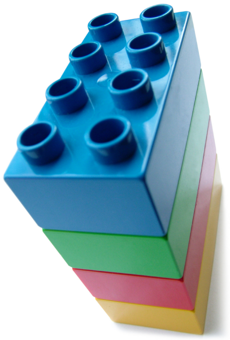
```
## [1] 2
```

```
pet <- "dog"
```

```
pet
```

```
## [1] "dog"
```

A.9 Combining Expressions



A.10 Complex Data Types

- Scalars, Vectors, Matrices, and Arrays
- Lists
- Dataframes

A.11 Grouping Homogeneous Data Types

- combining scalars

```
c()
```

- combining expressions

```
{}
```

- combining vectors

```
cbind()
rbind()
```

A.12 Complex Functions

- Vectorization
- Nested Functions
- Loops and Conditional execution

class: inverse, center, middle

A.13 Abstraction

A.14 Abstraction

- Assignment
-

A.15 Data Abstraction

A.16 Functional Abstraction

A.17 Anatomy of a Function

```
name <- function(arg_1, arg_2, ...) expression
```

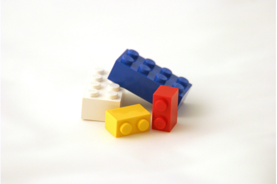
A.18 Teaching With A Statistical Programming Language

A.18.1 An Example

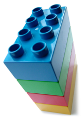
A.19 myMean

A.20 Basic Elements of a Good SPL

A rich set of **primitive expressions**



Mechanisms for **combining expressions** into more complex expressions



Means of **abstraction**, which allow for naming and manipulating compound objects

Bibliography

Judd, C. M., McClelland, G. H., and Ryan, C. S. (2017). *Data analysis: A model comparison approach to regression, ANOVA, and beyond*. Routledge.