

Week-3: Variables & their types

NM2207: Computational Media Literacy

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This week

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I. Variables

What are variables?

- In programming, a **variable** is a name given to locations in the memory of the computer
- They allow the user to *store* and *manipulate* data
-  has six **primitive** types of variables,
 1. character
 2. double (real numbers)
 3. integer
 4. complex
 5. logical
 6. raw

Note: Think of them to be wallets that hold data instead of currency!

Variables (continued)

- Each variable has four attributes
 1. an identifier (or name)
 2. location
 3. type
 4. value
- The *identifier* and *value* are assigned by the user
 - Remember to always give names that are meaningful and related to the data
 - Avoid using space between characters/words in the name
- The *value* assigned by the user determines its *type*
- The *location* and *type* are automatically assigned, unless the user desires to override them

Variables: Classification

Variables can be broadly classified into two kinds,

1. Numeric variables

- a. Continuous
- b. Discrete

2. Non-numeric variables/Categoric

- a. Ordinal
- b. Nominal
- c. Binary

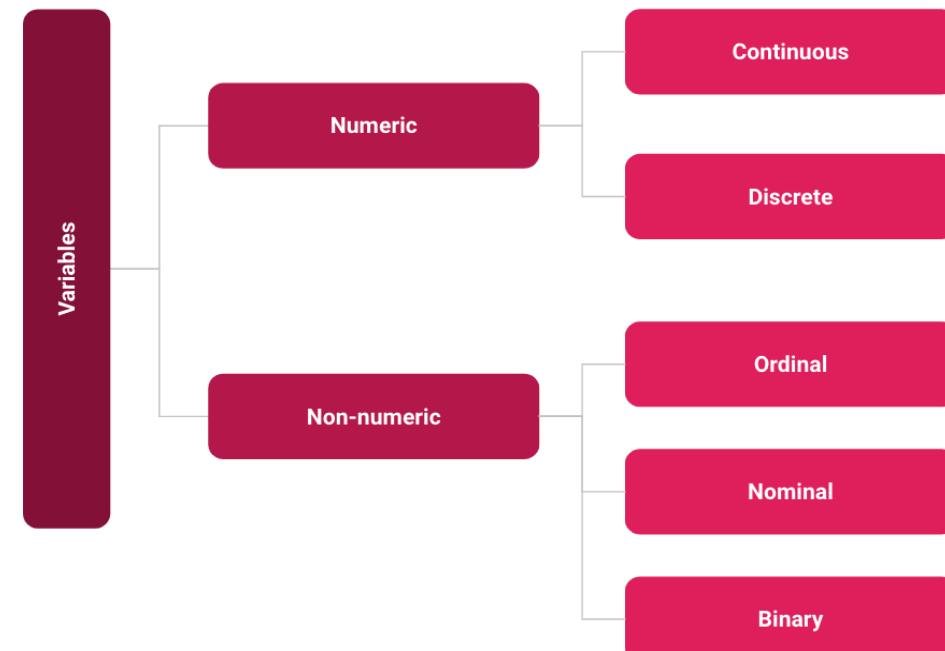


Figure: Classification of variables

Variables: Numeric

Numeric variables could be one of the following, numbers can be positive/negative

1. **integer**: are whole numbers, *without* decimal values

Examples

1000, 100, 200, 0, 1, 121353346970980,-1,-10

2. **double**: are numbers *with* decimal values

Examples

1.1, 0.89, 200.0, 0.001, 1000.5090809090068,-0.98,-200.0

3. **complex**: are *imaginary* numbers

Examples

1i, 2+10i, -200, 0.001, 1000.5090809090068-896.43124319i

Numeric variables: classification

They can be **continuous**

- Of *type double*
- Can have **infinite decimal** values

Examples

Weight, Temperature, Height

They can also be **discrete**

- Of *type integer or double*
- They are **finite**

Examples

Population, Number of occurrences

CONTINUOUS

measured data, can have ∞ values within possible range.



I AM 3.1" TALL

I WEIGH 34.16 grams

DISCRETE

OBSERVATIONS CAN ONLY EXIST
AT LIMITED VALUES, OFTEN COUNTS.



I HAVE 8 LEGS
and
4 SPOTS!

@allison_horst

Non-numeric variables: Categoric

Non-numeric variables are also called categoric variables. Additionally, they can be,

1. **character**: **single** alphabet or numeral

Examples **single quotes** 单引号

'A', 'v', 'X', 'P', 'd', '1', '2'

2. **character**: **string** of alphabets or numerals

Examples

"hello", "world", "hi there", "20"

3. **logical**: either **TRUE** or **FALSE**

Note: **Character variables** can be enclosed either within **single** or **double quotes**. However, the practice is to use **single** quotes for a character and **double** quotes for a string of characters.

Categoric variables: Ordinal

| Categoric variables can be ordinal

- They can be of type - **character**
- They have *natural ordering*

Examples

Survey responses ("Strongly agree", "Agree", "Neutral", "Disagree", "Strongly disagree")

Survey responses ("Low", "Medium", "High")



Source: <https://allisonhorst.com/everything-else>

Categoric variables: Nominal

| Categoric variables can be nominal

- They can be of either types - **character** or **logical**
- They *do not* have a natural ordering

Examples

Gender ("Male", "Female")

Color ("Red", "Blue", "Green")



Source: <https://allisonhorst.com/everything-else>

Categoric variables: Binary

Categoric variables can also be binary

- They can be of either types - **character**, **logical** or **numeric**
- They *do not* have a natural ordering
- They take only two **mutually exclusive** values

Examples

"Yes", "No"

"TRUE", "FALSE"

1, 0



Source: <https://allisonhorst.com/everything-else>

Working with variables in

a. character

```
x <- 'A'
```

b. character (string)

```
x <- "Apple"
```

c. logical

```
x <- FALSE
```

d. integer

L succeeding the value that is assigned to X indicating that we want to create an integer

```
x <- 5L
```

e. numeric (double)

```
x <- 5
```

f. complex

```
x <- 1i
```

Notice how numeric assignments in d and e differ



Working with variables in

```
x <- 'A'  
typeof(x)
```

```
x <- 5L  
typeof(x)
```

```
## [1] "character"
```

```
## [1] "integer"
```

```
x <- "Apple"  
typeof(x)
```

```
x <- 5  
typeof(x)
```

```
## [1] "character"
```

```
## [1] "double"
```

```
x <- FALSE  
typeof(x)
```

```
x <- 1i  
typeof(x)
```

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

```
## [1] "complex"
```

Need for data types

Example: Cat lovers

A survey asked respondents their name and number of cats. The instructions said to enter the number of cats as a numerical value.

```
cat_lovers <- read_csv("cat-lovers.csv")  
  
## # A tibble: 60 × 3  
##   name      number_of_cats handedness  
##   <chr>        <chr>       <chr>  
## 1 Bernice Warren 0           left  
## 2 Woodrow Stone  0           left  
## 3 Willie Bass   1           left  
## 4 Tyrone Estrada 3          left  
## 5 Alex Daniels  3           left  
## 6 Jane Bates   2           left  
## 7 Latoya Simpson 1          left  
## 8 Darin Woods   1           left  
## 9 Agnes Cobb    0           left  
## 10 Tabitha Grant 0          left  
## # i 50 more rows
```

Example: Cat lovers

```
mean(cat_lovers$number_of_cats)
```

```
## Warning in mean.default(cat_lovers$number_of_cats): argument is not numeric or
## logical: returning NA
```

```
## [1] NA
```

Example: Cat lovers (Continued)

?mean

mean {base}

R Documentation

Arithmetic Mean

Description

Generic function for the (trimmed) arithmetic mean.

Usage

```
mean(x, ...)
```

```
## Default S3 method:
```

```
mean(x, trim = 0, na.rm = FALSE, ...)
```

Arguments

x An R object. Currently there are methods for numeric/logical vectors and [date](#), [date-time](#) and [time interval](#) objects. Complex vectors are allowed for `trim = 0`, only.

trim the fraction (0 to 0.5) of observations to be trimmed from each end of **x** before the mean is computed. Values of `trim` outside that range are taken as the nearest endpoint.

na.rm a logical evaluating to TRUE or FALSE indicating whether NA values should be stripped before the computation proceeds.

... further arguments passed to or from other methods.

Value

If `trim` is zero (the default), the arithmetic mean of the values in **x** is computed, as a numeric or complex vector of length one. If **x** is not logical (coerced to numeric), numeric (including integer) or complex, `NA_real_` is returned, with a warning.

If `trim` is non-zero, a symmetrically trimmed mean is computed with a fraction of `trim` observations deleted from each end before the mean is computed.

References

Example: Cat lovers - Coercion

```
mean(as.integer(cat_lovers$number_of_cats))
```

```
## Warning in mean(as.integer(cat_lovers$number_of_cats)): NAs introduced by
## coercion
```

```
## [1] NA
```

Example: Cat lovers - Investigation

```
cat_lovers$number_of_cats
```

1. some row contains texts, not completely numeric
2. when try to convert non-numerals into numerals, NA occurs in non-numeric entries (same when there are both numbers and texts present)

once NA occurs, the output of the mean function will also be in NA

```
## [1] "0"  
## [2] "0"  
## [3] "1"  
## [4] "3"  
## [5] "3"  
## [6] "2"  
## [7] "1"  
## [8] "1"  
## [9] "0"  
## [10] "0"  
## [11] "0"  
## [12] "0"  
## [13] "1"  
## [14] "3"  
## [15] "3"  
## [16] "2"  
## [17] "1"  
## [18] "1"  
## [19] "0"  
## [20] "0"  
## [21] "1"
```

Example: Cat lovers - Investigation (Continued)

```
as.integer(cat_lovers$number_of_cats)
```

```
## Warning: NAs introduced by coercion
```

```
## [1] 0 0 1 3 3 2 1 1 0 0 0 0 1 3 3 2 1 1 0 0 1 0 4
## [26] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 3 3 2 1 1 0 0 0 0
## [51] 1 0 1 NA 1 1 1 0 0 2
```

II. Data Structures

What are data structures

- They are a collection of values, of one or more types
- Data structures in **R** include the below types,
 - (atomic) vectors
 - lists
 - matrix
 - factors
- Among them, lists and vectors are the most common and basic data structures in **R**
- They are pretty much the workhorses of **R**

Note: Imagine a wallet that can store currencies of one or more nationalities

Vectors & their types

- A vector is a collection of elements of the same type
- They could be of type, character, logical, integer or double
- Let us create an empty vector `x`

```
# An empty vector
x <- vector()
```

- By default, the *type* of an empty vector is logical

```
# Type of the empty vector
typeof(x)
```

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

Vectors & their types

One can be more explicit and create vectors of the needed *type*

- Different ways to create vectors of *type*, **logical**

element of X may not be the same every time you run, cuz they are randomly generated

```
# Different ways to create vectors: method
x<-vector("logical",length=5)
```

```
# Different ways to create vectors: method
x<-logical(5)
```

```
# Different ways to create vectors: method
x<-c(TRUE,FALSE,TRUE,FALSE,TRUE)
```

if you require a vector where the elements are arranged in a certain sequences, the vector X will have the entries exactly as you specify them

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

- Different ways to create vectors of *type*, **character**

```
# Different ways to create vectors: method
x<-vector("character",length=5)
```

```
# Different ways to create vectors: method
x<-character(5)
```

```
# Different ways to create vectors: method
x<-c('A','b','r','q')
```

```
typeof(x)
```

```
## [1] "character"
```

Vectors & their types

One can be more explicit and create vectors of the needed *type*

- Different ways to create vectors of *type*, **integer**

```
# Different ways to create vectors: method
x<-vector("integer",length=5)

# Different ways to create vectors: method
x<-integer(5)

# Different ways to create vectors: method
x<-c(1,2,3,4,5)          you want to create a vector starting
                           from 1to 5, but insteps of 0.1
# Different ways to create vectors: method
x<-seq(from=1,to=5,by=0.1)

# Different ways to create vectors: method
x<-1:5                  1 to 5, in step of one, we cannot vary the steps of
                           increment
typeof(x)
```

```
## [1] "integer"
```

- Different ways to create vectors of *type*, **double**

```
# Different ways to create vectors: method
x<-vector("double",length=5)

# Different ways to create vectors: method
x<-double(5)

# Different ways to create vectors: method
x<-c(1.787,0.63573,2.3890)          if you want to create a custom vector, use c
                                         followed the bracket and pass all the values
                                         you want to assign to the variable
typeof(x)
```

```
## [1] "double"
```

Vectors: mixed types

If elements of the vector differ in their types,

- **R** will convert the vector to accommodate all the element types
- This automatic conversion by **R** from one type to another is called **coercion**
- When **R** converts the type based on its contents it is called, **implicit** coercion
- **Forcing** conversion manually is called, **explicit** coercion

when R carries out the conversion of a vector from one data type to another based on our inputs

Implicit coercion

Example 1: Automatic conversion of *types* by  from double to character

```
# Create a vector
x <- c(1.8)
# Check the type of x
typeof(x)
```

```
## [1] "double"
```

```
# Add a character to the vector
x <- c(x, 'a')
# Check the type of x
typeof(x)
```

```
## [1] "character"
```

Note: how `c()` is used to insert elements to a vector

Implicit coercion

Example 2: Automatic conversion of *types* by  from logical to double

```
# Create a vector
x <- c(TRUE)
# Check the type of x
typeof(x)
```

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

```
# Add a number to the vector
x <- c(x, 2)
# Check the type of x
typeof(x)
```

```
## [1] "double"
```

Note: how `c()` is used to insert elements to a vector

Implicit coercion

Example 3: Automatic conversion of *types* by  from character to character

```
# Create a vector
x <- c('a')
# Check the type of x
typeof(x)
```

```
## [1] "character"
```

```
# Add a logical value to the vector
x <- c(x, TRUE)
# Check the type of x
typeof(x)
```

```
## [1] "character"
```

Note: how `c()` is used to insert elements to a vector

Implicit coercion

Example 4: Automatic conversion of *types* by  from integer to double

```
# Create a vector
x <- c(1L)
# Check the type of x
typeof(x)
```

```
## [1] "integer"
```

```
# Add a number to the vector
x <- c(x, 2)
# Check the type of x
typeof(x)
```

```
## [1] "double"
```

Note: how `c()` is used to insert elements to a vector

Explicit coercion

Example 1: Explicit coercion from integer to character

```
# Create a vector
x <- c(1L)
# Check the type of x
typeof(x)
```

```
## [1] "integer"
```

```
# Convert the vector to type character
x <- as.character(x)
# Check the type of x
typeof(x)
```

```
## [1] "character"
```

Note: how `as.character()` is used for conversion

Explicit coercion

Example 2: Explicit coercion from character to double

```
# Create a vector
x <- c('A')
# Check the type of x
typeof(x)
```

```
## [1] "character"
```

```
# Convert the vector to type double
x <- as.numeric(x)
# Check the type of x
typeof(x)
```

```
## [1] "double"
```

Note: how `as.numeric()` is used for conversion

Accessing elements of a vector

Consider the following vector,

```
# Create a vector
x <- c(1,10,9,8,1,3,5)
```

a. Accessing the elements by index: one element

```
# One index
x[3]
```

```
## [1] 9
```

b. Accessing the elements by index: many elements

```
# Consecutive indices
x[2:4]
```

```
## [1] 10 9 8
```

```
# Non-consecutive indices
x[c(1,3,5)]
```

```
## [1] 1 9 1
```

Accessing elements of a vector

Consider the following vector,

```
# Create a vector
x <- c(1,10,9,8,1,3,5)
```

c. Accessing elements using a logical vector

```
# Use of logical vector
x[c(TRUE, FALSE, FALSE, TRUE, FALSE, FALSE, TRUE)]
```

```
## [1] 1 8 5
```

d. Accessing elements using conditional operator

```
# Use of conditional operator
x[x<10]
```

```
## [1] 1 9 8 1 3 5
```

Examining vectors

a. Number of elements in a vector

```
# length of the vector  
length(x)
```

```
## [1] 7
```

b. type of the object

```
# class of the vector  
typeof(x)
```

```
## [1] "double"
```

c. Display the structure of the object

```
# structure of the vector  
str(x)
```

```
## num [1:7] 1 10 9 8 1 3 5
```

- It is of class num, **numeric**
- It has 7 elements, [1:7]

Lists

A list is a special vector whose elements can be of varied types

a. Creating a list

```
# Initialise a list
x<-list(1,"a",0.289,TRUE)
```

b. Conversion to a list: vector to list

```
# Initialise a vector
x<-c(1,2,3,4,10)
# Convert to a list
x<-as.list(x)
```

Lists

- Elements of a list can be named
- A list is printed on the console along with the name
- Each element of the list starts on a new line

Example

```
# Initialise a named list
my_pie = list(type="key lime", diameter=7, is_vegetarian=TRUE)
```

```
## $type
## [1] "key lime"
##
## $diameter
## [1] 7
##
## $is.vegetarian
## [1] TRUE
```

Lists

a. Print names of the list

```
# Elicit names of the list
names(my_pie)
```

```
## [1] "type"           "diameter"        "is.vege
```

b. Access elements of the list by their name

```
# Retrieve the element named type
my_pie$type
```

```
## [1] "key lime"
```

c. Access elements of the list using []: returns a list

```
# Retrieve a truncated list
my_pie["type"]
```

```
## $type
## [1] "key lime"
```

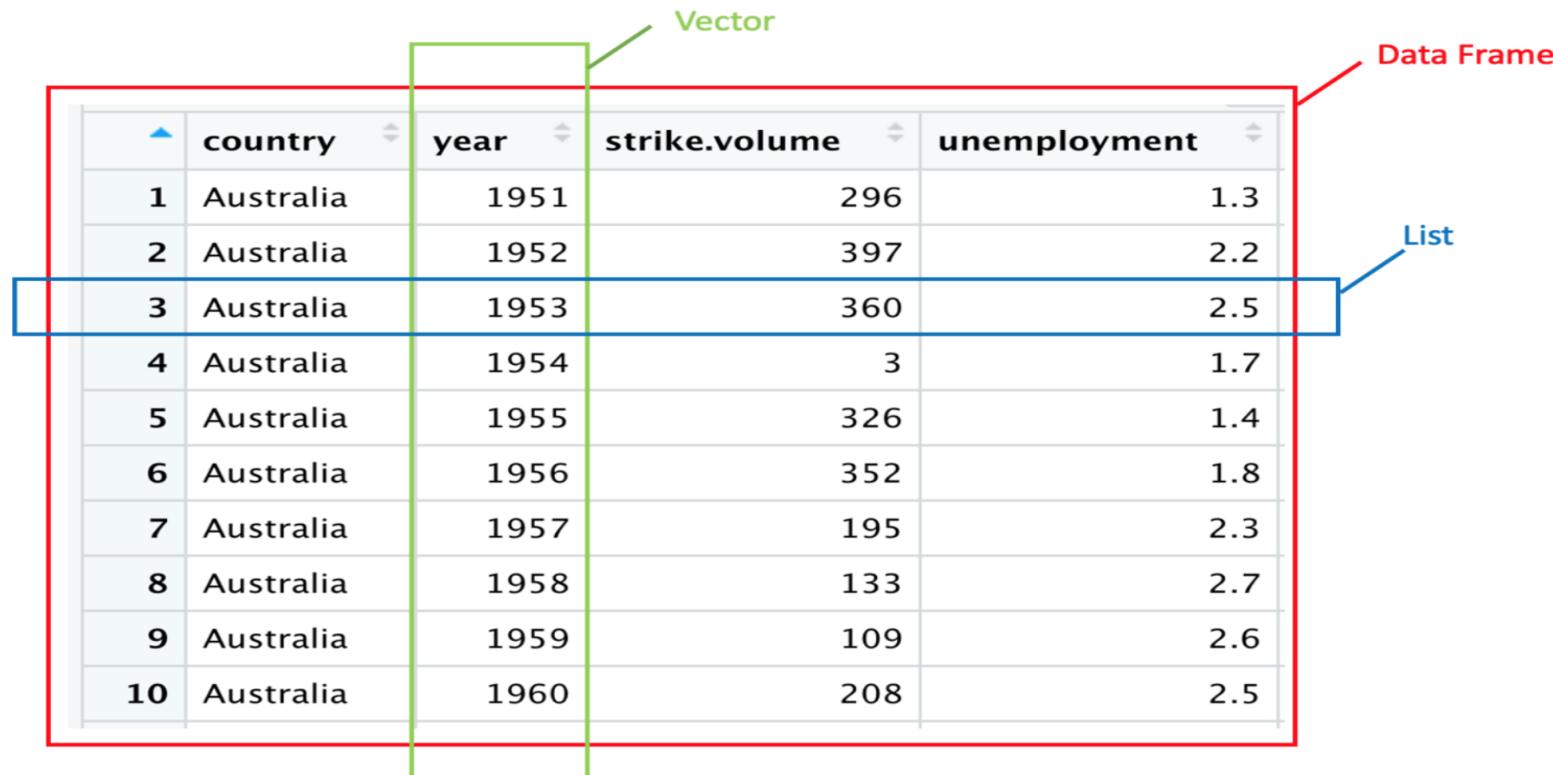
d. Access elements of the list using [[]]: returns the element

```
# Retrieve the element named type
my_pie[["type"]]
```

```
## [1] "key lime"
```

Data-set overview

A data frame is a collection of vectors.



	country	year	strike.volume	unemployment
1	Australia	1951	296	1.3
2	Australia	1952	397	2.2
3	Australia	1953	360	2.5
4	Australia	1954	3	1.7
5	Australia	1955	326	1.4
6	Australia	1956	352	1.8
7	Australia	1957	195	2.3
8	Australia	1958	133	2.7
9	Australia	1959	109	2.6
10	Australia	1960	208	2.5

III. Exploring a data-set

Let us explore a data-set

Example data-set

- Let us consider a data-set, **Lending club**
- The data-set is from a platform that enables loans between individuals
- Not all requests are treated equally;
 - Approval of loan is dependent on the borrower's ability to repay
- The data-set has a compilation of all sanctioned loans
 - There are no loan applications

Lending club: packages

- Install the package containing the data-set

```
# Install package
install.packages("openintro")
```

- Load the installed package

```
# Load package
library(openintro)
```

```
## Loading required package: airports
```

```
## Loading required package: cherryblossom
```

```
## Loading required package: usdata
```

Lending club: packages

- Load `tidyverse` package to manipulate the data-set

```
# Load package
library(tidyverse)
```

Lending club: overview

An overview of the contents of the data-set

```
#> # Catch a glimpse of the data-set
#> glimpse(loans_full_schema)
```

```
## Rows: 10,000
## Columns: 55
## $ emp_title
## $ emp_length
## $ state
## $ homeownership
## $ annual_income
## $ verified_income
## $ debt_to_income
## $ annual_income_joint
## $ verification_income_joint
## $ debt_to_income_joint
## $ delinq_2y
## $ months_since_last_delinq
## $ earliest_credit_line
## $ inquiries_last_12m
## $ total_credit_lines
## $ open_credit_lines
```

```
<chr> "global config engineer ", "warehouse...
<dbl> 3, 10, 3, 1, 10, NA, 10, 10, 10, 3, 1...
<fct> NJ, HI, WI, PA, CA, KY, MI, AZ, NV, I...
<fct> MORTGAGE, RENT, RENT, RENT, RENT, OWN...
<dbl> 90000, 40000, 40000, 30000, 35000, 34...
<fct> Verified, Not Verified, Source Verifi...
<dbl> 18.01, 5.04, 21.15, 10.16, 57.96, 6.4...
<dbl> NA, NA, NA, NA, 57000, NA, 155000, NA...
<fct> , , , , Verified, , Not Verified, , ...
<dbl> NA, NA, NA, NA, 37.66, NA, 13.12, NA...
<int> 0, 0, 0, 0, 0, 1, 0, 1, 1, 0, 0, 0, 0...
<int> 38, NA, 28, NA, NA, 3, NA, 19, 18, NA...
<dbl> 2001, 1996, 2006, 2007, 2008, 1990, 2...
<int> 6, 1, 4, 0, 7, 6, 1, 1, 3, 0, 4, 4, 8...
<int> 28, 30, 31, 4, 22, 32, 12, 30, 35, 9...
<int> 10, 14, 10, 4, 16, 12, 10, 15, 21, 6...
```

Lending club: Numeric variables

Let us select some variables of *type* Numeric,

a. pass the data-set through a pipe operator (`%>%`)

b. `select()` variables of interest

- `paid_total`
- `term`
- `interest_rate`
- `annual_income`
- `paid_late_fees`
- `debt_to_income`

```
loans <- loans_full_schema %>% # <-- pipe ope.  
  select(paid_total, term, interest_rate,  
         annual_income, paid_late_fees, debt_to.  
glimpse(loans)
```

```
## Rows: 10,000  
## Columns: 6  
## $ paid_total      <dbl> 1999.330, 499.120, 28  
## $ term           <dbl> 60, 36, 36, 36, 36, .  
## $ interest_rate   <dbl> 14.07, 12.61, 17.09,  
## $ annual_income    <dbl> 90000, 40000, 40000,  
## $ paid_late_fees  <dbl> 0, 0, 0, 0, 0, 0,  
## $ debt_to_income   <dbl> 18.01, 5.04, 21.15,
```

Lending club: Numeric variables

Variable	Description
paid_total	Repaid loan amount, in US dollars
term	The length of the loan, which is always set as a whole number of months
interest_rate	Interest rate on the loan, in an annual percentage
annual_income	Borrower's annual income, including any second income, in US dollars
paid_late_fees	Penalty paid for defaulting on payment of interest, in US dollars
debt_to_income	Debt-to-income ratio

Lending club: classification of Numeric variables

Variable	Type
paid_total	Continuous
term	Discrete
interest_rate	Continuous
annual_income	Continuous
paid_late_fees	Continuous
debt_to_income	Continuous

Lending club: overview revisited

```
# overview of the data-set  
glimpse(loans_full_schema)
```

Lending club: Categoric variables

Let us select some variables of *type* Categoric,

a. pass the data-set through a pipe operator (`%>%`)

b. `select()` variables of interest

- `grade`
- `state`
- `homeownership`
- `disbursement_method`

```
loans <- loans_full_schema %>% # <-- pipe ope.
  select(grade,state,homeownership,disburseme)
glimpse(loans)
```

```
## Rows: 10,000
## Columns: 4
## $ grade           <fct> C, C, D, A, C, I
## $ state           <fct> NJ, HI, WI, PA,
## $ homeownership   <fct> MORTGAGE, RENT,
## $ disbursement_method <fct> Cash, Cash, Casl
```

Lending club: Categoric variables

Variable	Description
grade	Loan grade, which takes values A through G and represents the quality of the loan and its likelihood of being repaid
state	US state where the borrower resides
homeownership	Indicates whether the person owns, owns but has a mortgage, or rents
disbursement	Mode of loan disbursement

Lending club: classification of Categoric variables

Variable	Type
grade	Ordinal
state	Nominal
homeownership	Nominal
disbursement	Nominal

Thanks!

Slides created via the  packages:

xaringan
gadenbuie/xaringanthemer.



Faculty of Arts
& Social Sciences