01-09: Multiple Conditions

1 - Purpose

- introduce the logical operators and use them to combine conditions in a conditional statement
- create conditional statements that check for multiple values on a single variable
- create conditional statements that check the value of multiple variables

2 - Concepts

3 - More Complex Decisions

Until now our conditional statements have only checked one condition (e.g., Is the animal a llama? Is the temperature greater than 50? Did the fish get caught from north port?). However, we often care about multiple conditions (e.g., Is the animal a llama ***or*** *an alpaca*? Is the *temperature between 50* ***and*** *80*?, Did the fish get caught from north port ***or*** south port?).

Multiple conditions in English are almost always denoted by the words ***and*** and ***or.*** In R, there are operators that represent ***and*** and ***or*** called *logical operators*. ***and*** is represent by ***&&*** while ***or*** is represented by *||*.

Operator Type	**Purpose**	**R Symbols**
Assignment	Assign a value to a variable	= or <-
Mathematical	Perform a mathematical operation on a numeric value	+, -, *, /, ^
Conditional	Compare two values	==, !=, >, <, >=, <=
Logical	Combine conditions	&&, ||, &, |

Extension: The single character logical operators ***&*** and *|*

3.1 - Checking for multiple spellings of a word

A couple of lesson ago we asked the user for their favorite cheese and, of course, the answer is "Muenster". However, "Muenster" is not the easiest word to spell -- for example, it is often misspelled "Meunster". We can make our script more robust by using logical operators to check for alternative spellings (e.g., multiple conditions).

Instead of asking: Is ***favCheese*** equal to "Muenster"?
We want to ask: Is ***favCheese*** equal to "M*ue*nster" ***or*** "M*eu*nster"?

But in programming, we need to be more explicit and ask:
Is ***favCheese*** equal to "M*ue*nster" ***or*** is ***favCheese*** equal to "M*eu*nster"?

In R this is written as:

```
if( favCheese == "Muenster" || favCheese == "Meunster" )
```

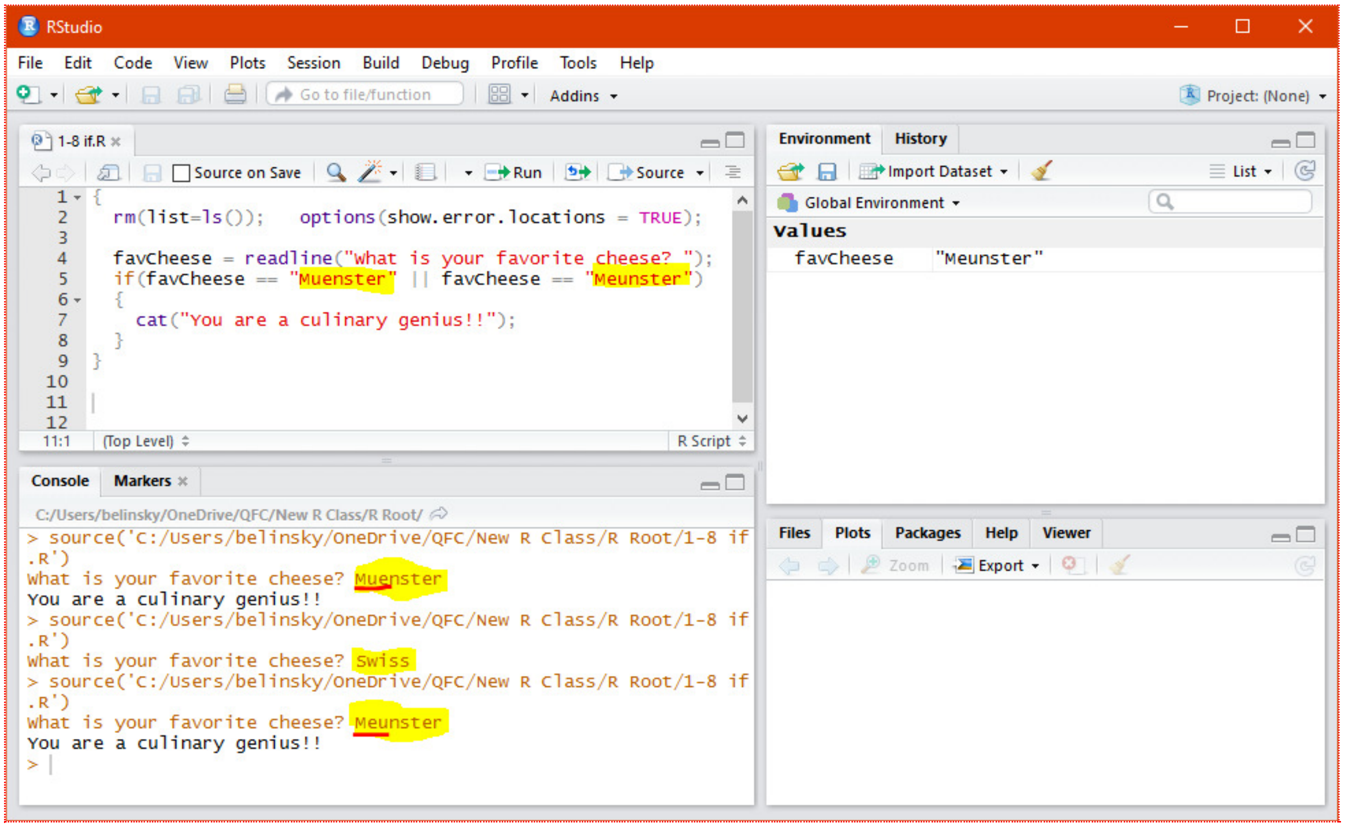
4 - The *or* operator (||) -- checking 2 conditions

We can put the above ***favCheese*** conditions into one conditional statement by using the ***or*** operator. The symbol for the ***or*** operator is (*||*). *Extension: || on the keyboard*. The ***or*** operator takes two conditions and returns ***TRUE*** *if either condition* is ***TRUE*** and returns ***FALSE*** only if both conditions are ***FALSE.***

```
{
  rm(list=ls());   options(show.error.locations = TRUE);

  favCheese = readline("What is your favorite cheese? ");
  if(favCheese == "Muenster" || favCheese == "Meunster")
  {
     cat("You are a culinary genius!!");
  }
}
```

The above code will execute the "culinary genius" codeblock if the user entered either spelling of "Muenster".



```
{
  rm(list=ls());   options(show.error.locations = TRUE);

  favCheese = readline("what is your favorite cheese? ");
  if(favCheese == "Muenster" || favCheese == "Meunster")
  {
    cat("You are a culinary genius!!");
  }
}
```

```
Values
  favCheese      "Meunster"
```

```
C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/1-8 if
.R')
What is your favorite cheese? Muenster
You are a culinary genius!!
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/1-8 if
.R')
What is your favorite cheese? Swiss
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/1-8 if
.R')
What is your favorite cheese? Meunster
You are a culinary genius!!
> |
```

Fig 1: Using or (||) to checking for two different spellings of our favorite cheese

Note: If there are multiple conditions then *each condition must be explicitly stated*. R will faithfully execute the following code but the result will be ***TRUE*** no matter what the user enters.

```
# error: need to be explicit about the conditions
if(favCheese == "Muenster" || "Meunster")
{
   cat("I will always be executed because there is
                 a logical error in the conditional statement");
}
```

We talk more about this issue here-- *Trap: All conditional statements must be explicitly stated*

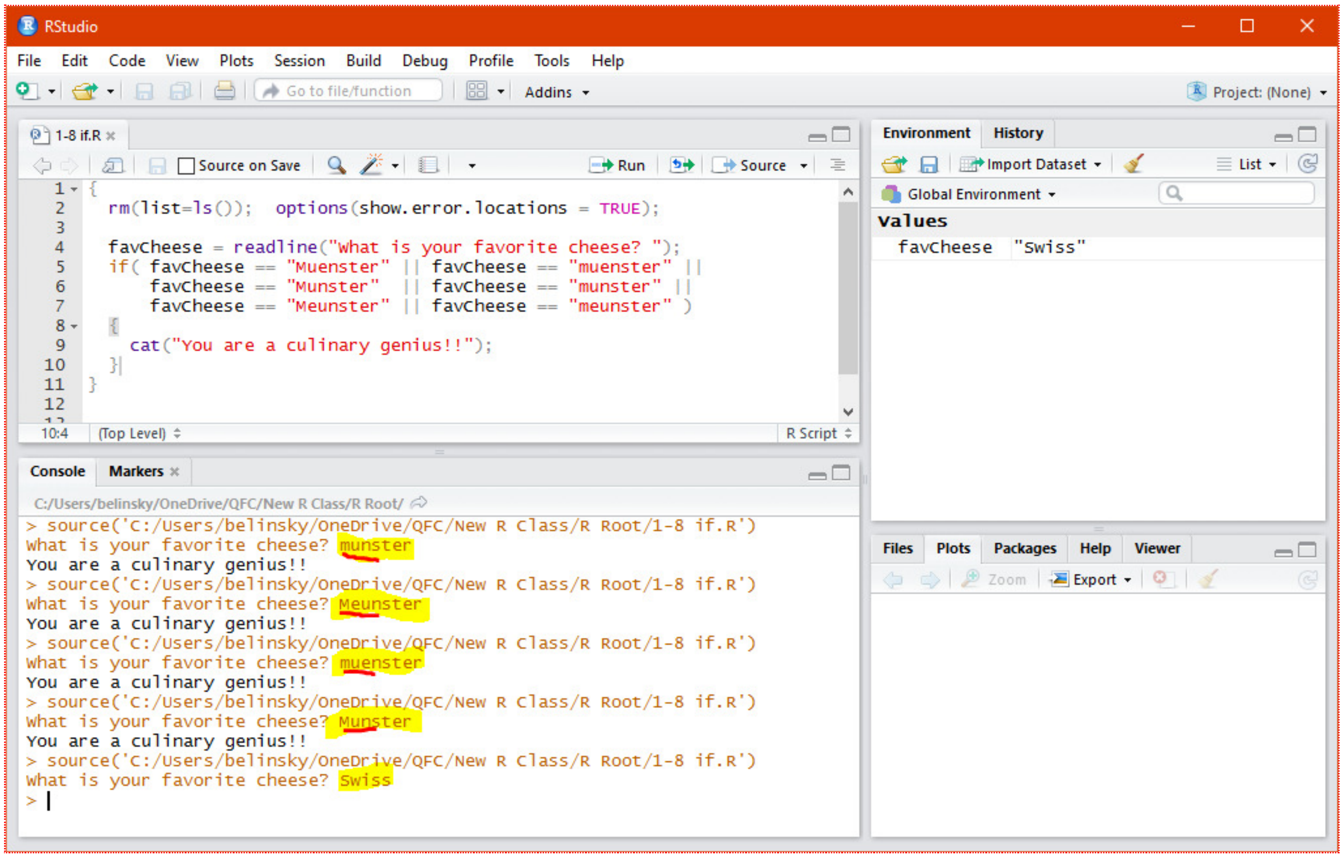
4.1 - The *or* operator (||) -- checking more than 2 conditions

We can use the (*||*) to check for more variations of "Muenster". The conditional statement in the script below checks six variations of "Muenster" and returns ***TRUE*** if ***favCheese*** matches *any of the six spellings*.

```
{
  rm(list=ls());  options(show.error.locations = TRUE);

  favCheese = readline("What is your favorite cheese? ");
  if( favCheese == "Muenster" || favCheese == "muenster" ||
      favCheese == "Munster"  || favCheese == "munster" ||
      favCheese == "Meunster" || favCheese == "meunster" )
  {
    cat("You are a culinary genius!!");
  }
}
```

Note: the conditional statement have been broken up into multiple line to make it easier to read.



```
{
  rm(list=ls());  options(show.error.locations = TRUE);

  favCheese = readline("what is your favorite cheese? ");
  if( favCheese == "Muenster" || favCheese == "muenster" ||
      favCheese == "Munster"  || favCheese == "munster"  ||
      favCheese == "Meunster" || favCheese == "meunster" )
  {
    cat("You are a culinary genius!!");
  }
}
```

```
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/1-8 if.R')
what is your favorite cheese? munster
You are a culinary genius!!
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/1-8 if.R')
what is your favorite cheese? Meunster
You are a culinary genius!!
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/1-8 if.R')
what is your favorite cheese? muenster
You are a culinary genius!!
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/1-8 if.R')
what is your favorite cheese? Munster
You are a culinary genius!!
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/1-8 if.R')
what is your favorite cheese? Swiss
> 
```

```
Values
  favCheese   "Swiss"
```

Fig 2: Multiple conditions allowing for many possible spelling of muenster (still have grammar error...)

5 - Getting a range of numbers: the and (&&) operator

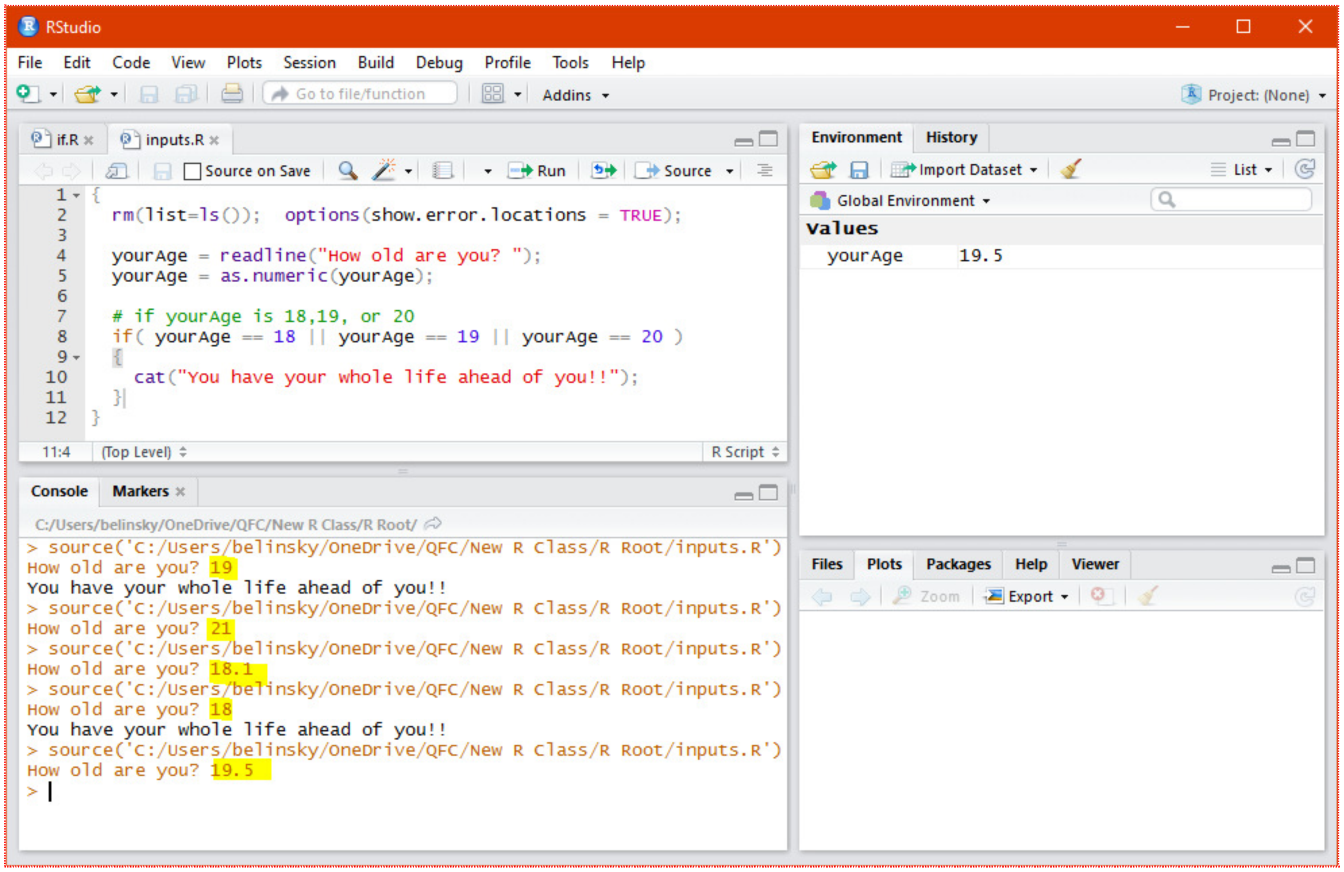
The (*||*) operator can also be used to check for different numeric value. For example if you want to output a message for anyone who is **18**, **19**, or **20** years old you can check the three conditions: ***(yourAge == 18)*** or (***yourAge == 19***) or (***yourAge == 20***).

```
{
  rm(list=ls());  options(show.error.locations = TRUE);

  yourAge = readline("How old are you? ");
  yourAge = as.numeric(yourAge);

  # if yourAge is 18,19, or 20
  if( yourAge == 18 || yourAge == 19 || yourAge == 20 )
  {
     cat("You have your whole life ahead of you!!");
  }
}
```

The conditional statement is only going to be ***TRUE*** for the integers **18**, **19**, and **20**. It will be ***FALSE*** for all other value, including decimal values like 18.5 or 20.1.



```
{
  rm(list=ls());  options(show.error.locations = TRUE);

  yourAge = readline("How old are you? ");
  yourAge = as.numeric(yourAge);

  # if yourAge is 18,19, or 20
  if( yourAge == 18 || yourAge == 19 || yourAge == 20 )
  {
    cat("You have your whole life ahead of you!!");
  }
}
```

```
Values
  yourAge      19.5
```

```
C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/inputs.R')
How old are you? 19
You have your whole life ahead of you!!
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/inputs.R')
How old are you? 21
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/inputs.R')
How old are you? 18.1
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/inputs.R')
How old are you? 18
You have your whole life ahead of you!!
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/inputs.R')
How old are you? 19.5
> |
```

Fig 3: Using or (||) to check for three different ages

This coding is unwieldy if you have a larger range of numbers. For example "all ages between **20** and **40**" would require **21** conditions:

```
if(yourAge == 20 || yourAge ==21 || yourAge == 22 ||
   yourAge == 23 || ... || yourAge == 40 )
```

And you would need an infinite number of conditions if you want to include all decimal numbers in between **20** and **40**.

6 - Multiple conditions using the and (&&) operator

We need to create a conditional statement that looks at a range of numbers (20 through 40) -- this is done with two conditions connected using the ***and*** operator (***&&***).

The picture (*Fig 4*) shows the overlap between two conditions that make up "all ages between **20** and **40**":
1) top blue arrow: (***yourAge > 20***)
2) bottom orange arrow: (***yourAge < 40***)

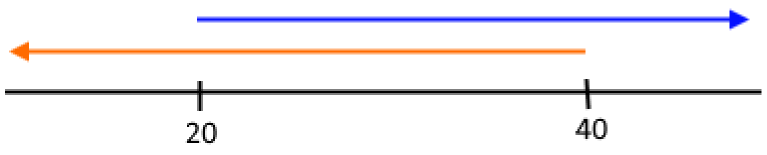


*Fig 4: Creating a range using the **&&** operator*

The overlap between the two arrows represents when the conditions (***yourAge*** > ***20***) and (***yourAge*** < ***40***) are both ***TRUE***.

In R the statement is:

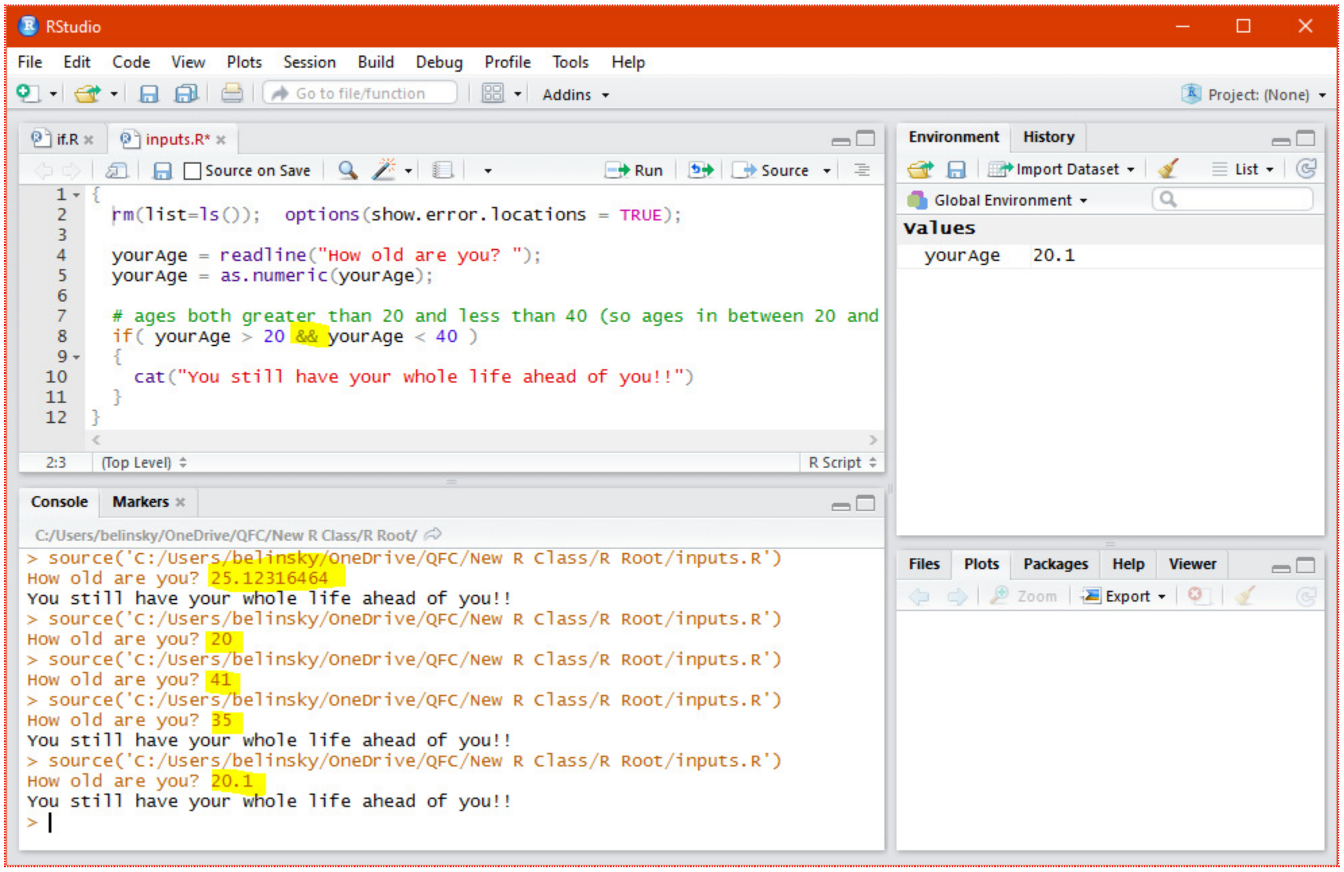
```
if (yourAge > 20 && yourAge < 40 )
```

And putting the above conditional statement into a script:

```
{
  rm(list=ls());  options(show.error.locations = TRUE);

  yourAge = readline("How old are you? ");
  yourAge = as.numeric(yourAge);

  # ages both greater than 20 and less than 40 (so ages in between 20 and 40)
  if( yourAge > 20 && yourAge < 40 )
  {
     cat("You still have your whole life ahead of you!!")
  }
}
```



```
{
  rm(list=ls());  options(show.error.locations = TRUE);

  yourAge = readline("How old are you? ");
  yourAge = as.numeric(yourAge);

  # ages both greater than 20 and less than 40 (so ages in between 20 and
  if( yourAge > 20 && yourAge < 40 )
  {
    cat("You still have your whole life ahead of you!!")
  }
}
```

```
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/inputs.R')
How old are you? 25.12316464
You still have your whole life ahead of you!!
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/inputs.R')
How old are you? 20
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/inputs.R')
How old are you? 41
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/inputs.R')
How old are you? 35
You still have your whole life ahead of you!!
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/inputs.R')
How old are you? 20.1
You still have your whole life ahead of you!!
>
```

*Fig 5: Using the **&&** operator to check a range of numbers*

Where ***or*** *(||)* outputs ***TRUE*** if either of the conditions are ***TRUE***, ***and*** *(* **&&** *)* outputs ***TRUE*** only *if both the conditions* are ***TRUE***.

6.1 - Checking the values of multiple variable using &&

The ***and*** (***&&***) operator can also be used to make conditional operations on multiple variables. For instance you might want to look for people who like llamas (***favAnimal == "Llama"***) and like Muenster cheese (***favCheese == "Muenster"***):

```
if( favAnimal == "Llama" && favCheese == "Muenster" )  # TRUE for this author
```

or you might want all fish under the age of 5 (***fishAge < 5***) that were caught at night (***catchTime == "night"***):

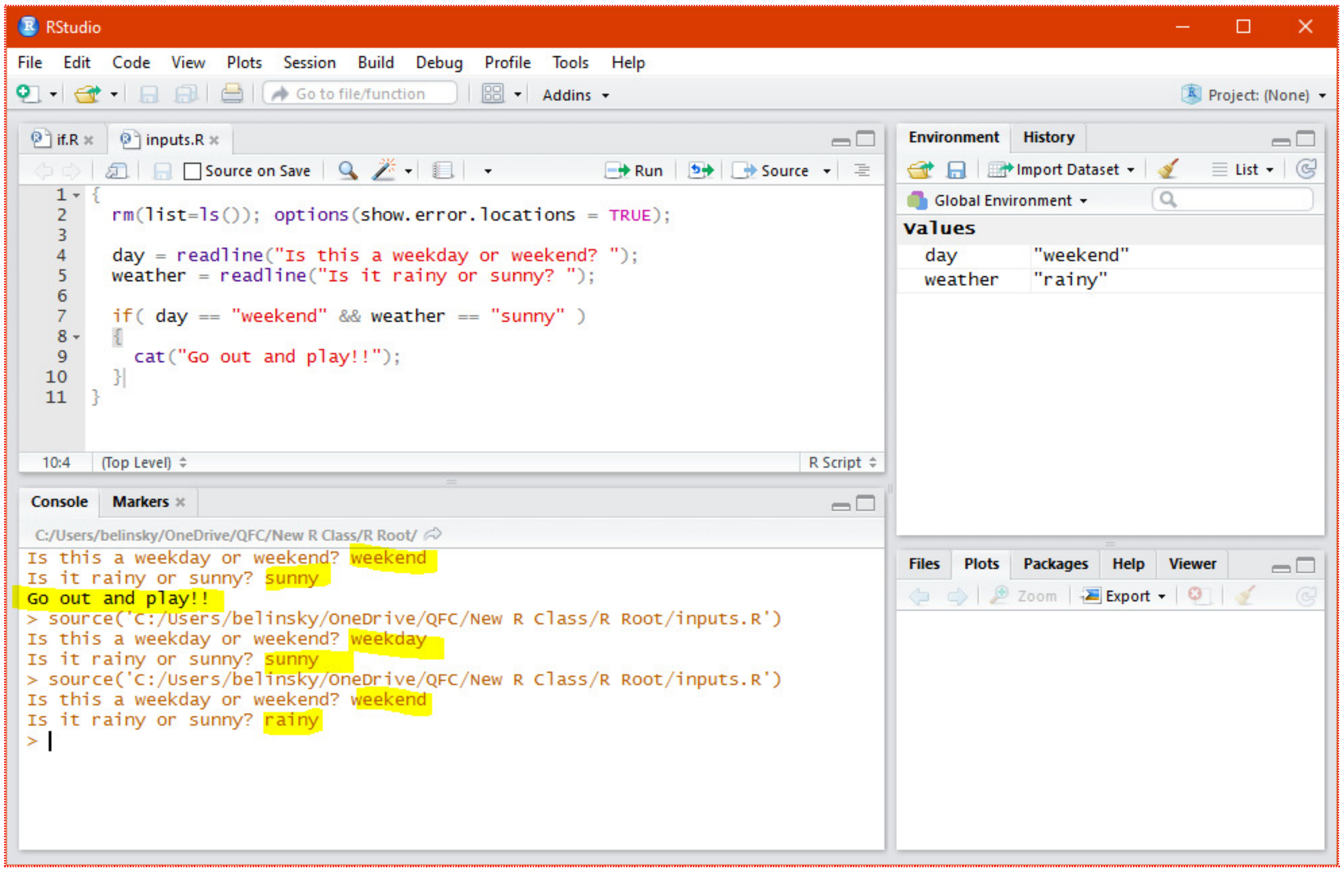
```
if( fishAge < 5 && catchTime == "night" )
```

Or, you might want a simple check of both day and weather:

```
{
  rm(list=ls()); options(show.error.locations = TRUE);

  day = readline("Is this a weekday or weekend? ");
  weather = readline("Is it rainy or sunny? ");

  if( day == "weekend" && weather == "sunny" )
  {
    cat("Go out and play!!");
  }
}
```



```
{
  rm(list=ls());  options(show.error.locations = TRUE);

  day = readline("Is this a weekday or weekend? ");
  weather = readline("Is it rainy or sunny? ");

  if( day == "weekend" && weather == "sunny" )
  {
    cat("Go out and play!!");
  }
}
```

```
C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/
Is this a weekday or weekend? weekend
Is it rainy or sunny? sunny
Go out and play!!
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/inputs.R')
Is this a weekday or weekend? weekday
Is it rainy or sunny? sunny
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/inputs.R')
Is this a weekday or weekend? weekend
Is it rainy or sunny? rainy
> 
```

day	"weekend"
weather	"rainy"

*Fig 6: Using **&&** to check the value of two different variables*

7 - If-else-if with the and (&&) operator

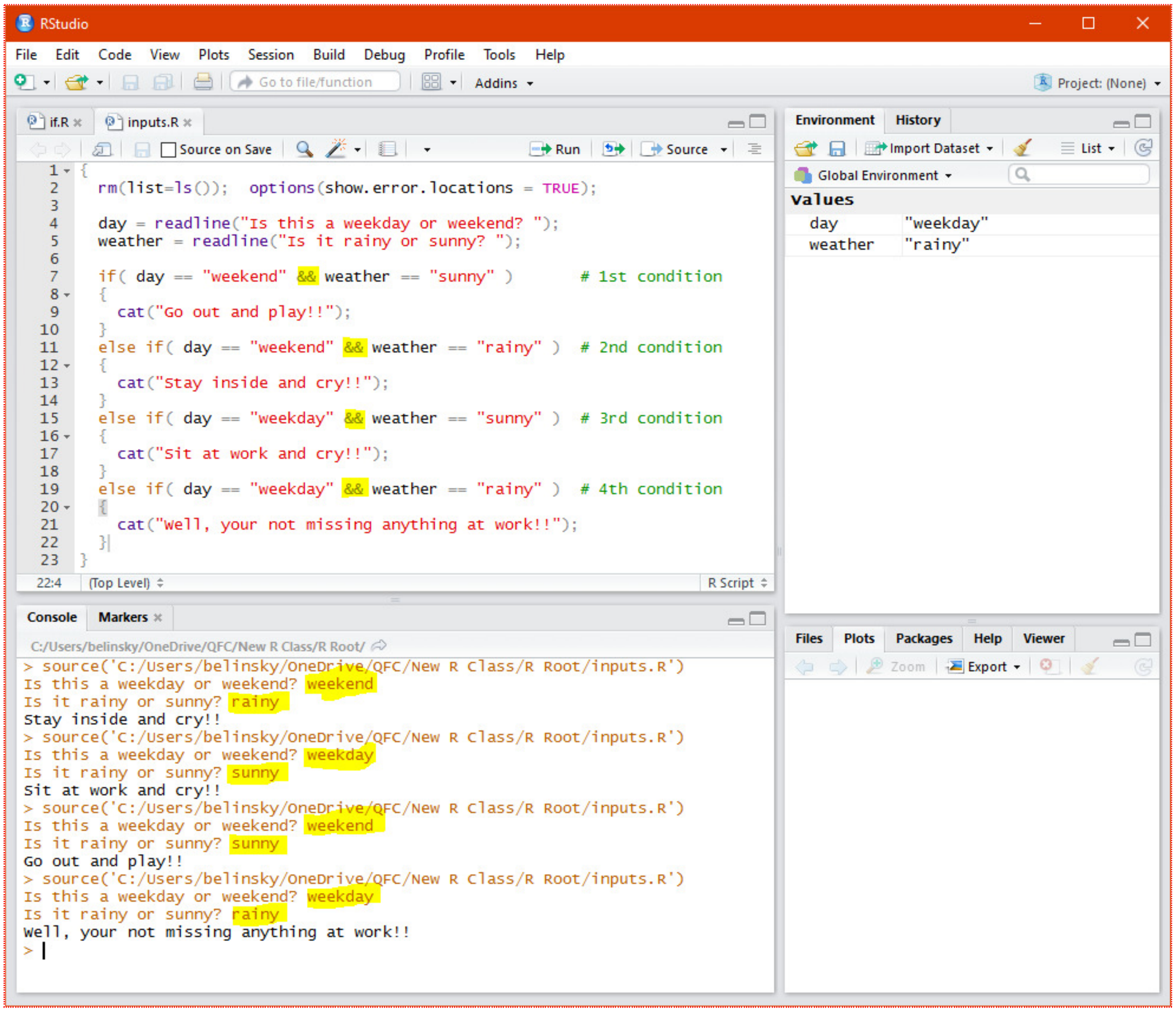
The above script (*Fig 6*) has two variables (***day*** and ***weather***) and each variable has two possible values (***weekday***,***weekend*** **&** ***sunny***,***rainy***).
This means there are *four possible combinations of day and weather:*
1) weekday/sunny
2) weekday/rainy
3) weekend/sunny
4) weekend/rainy

We can use an ***if-else-if*** structure to handle the four possible ***day/weather*** conditions and provide a different response for each of the four possibilities:

```
{
  rm(list=ls());  options(show.error.locations = TRUE);

  day = readline("Is this a weekday or weekend? ");
  weather = readline("Is it rainy or sunny? ");

  if( day == "weekend" && weather == "sunny" )       # 1st condition
  {
     cat("Go out and play!!");
  }
  else if( day == "weekend" && weather == "rainy" )  # 2nd condition
  {
     cat("Stay inside and cry!!");
  }
  else if( day == "weekday" && weather == "sunny" )  # 3rd condition
  {
     cat("Sit at work and cry!!");
  }
  else if( day == "weekday" && weather == "rainy" )  # 4th condition
  {
     cat("Well, your not missing anything at work!!");
  }
}
```



```
{
  rm(list=ls());  options(show.error.locations = TRUE);

  day = readline("Is this a weekday or weekend? ");
  weather = readline("Is it rainy or sunny? ");

  if( day == "weekend" && weather == "sunny" )       # 1st condition
  {
    cat("Go out and play!!");
  }
  else if( day == "weekend" && weather == "rainy" )  # 2nd condition
  {
    cat("Stay inside and cry!!");
  }
  else if( day == "weekday" && weather == "sunny" )  # 3rd condition
  {
    cat("Sit at work and cry!!");
  }
  else if( day == "weekday" && weather == "rainy" )  # 4th condition
  {
    cat("Well, your not missing anything at work!!");
  }
}
```

Values

day	"weekday"
weather	"rainy"

```
C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/inputs.R')
Is this a weekday or weekend? weekend
Is it rainy or sunny? rainy
Stay inside and cry!!
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/inputs.R')
Is this a weekday or weekend? weekday
Is it rainy or sunny? sunny
Sit at work and cry!!
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/inputs.R')
Is this a weekday or weekend? weekend
Is it rainy or sunny? sunny
Go out and play!!
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/inputs.R')
Is this a weekday or weekend? weekday
Is it rainy or sunny? rainy
Well, your not missing anything at work!!
> |
```

Fig 7: Checking the four possible ***day*** *and* ***weather*** *conditions*

7.1 - Using else as an error condition

In the previous script (*Fig 7*), the four possible combinations of day and weather are presented in the ***if-else-if*** structure and the script outputs a message for all four conditions. However, there is no message if all four conditions fails. In other words, we have no error condition.

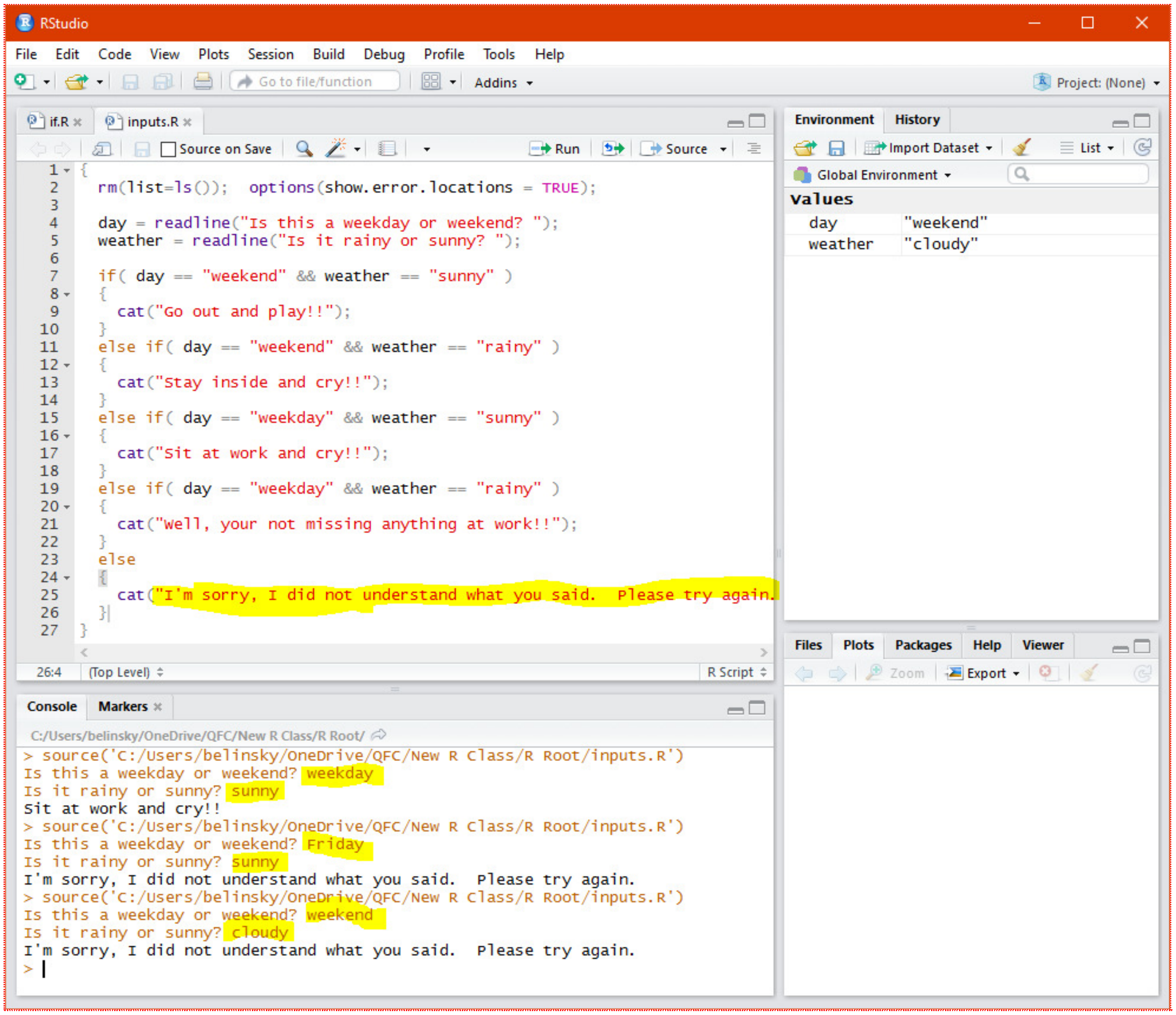
To add an *error condition*, we attach an ***else*** statement at the end of the ***if-else-if*** structure. The ***else*** statement is a waste-basket condition that captures anything the ***if-else-if*** structure missed.

So, we can take the above day/weather example and add an ***else*** as an error condition to capture every other possible input from the user:

```
{
  rm(list=ls());  options(show.error.locations = TRUE);

  day = readline("Is this a weekday or weekend? ");
  weather = readline("Is it rainy or sunny? ");

  if( day == "weekend" && weather == "sunny" )
  {
     cat("Go out and play!!");
  }
  else if( day == "weekend" && weather == "rainy" )
  {
     cat("Stay inside and cry!!");
  }
  else if( day == "weekday" && weather == "sunny" )
  {
     cat("Sit at work and cry!!");
  }
  else if( day == "weekday" && weather == "rainy" )
  {
     cat("Well, your not missing anything at work!!");
  }
  else
  {
    cat("I'm sorry, I did not understand what you said.  Please try again.");
  }
}
```



```
{
  rm(list=ls());  options(show.error.locations = TRUE);

  day = readline("Is this a weekday or weekend? ");
  weather = readline("Is it rainy or sunny? ");

  if( day == "weekend" && weather == "sunny" )
  {
    cat("Go out and play!!");
  }
  else if( day == "weekend" && weather == "rainy" )
  {
    cat("Stay inside and cry!!");
  }
  else if( day == "weekday" && weather == "sunny" )
  {
    cat("Sit at work and cry!!");
  }
  else if( day == "weekday" && weather == "rainy" )
  {
    cat("Well, your not missing anything at work!!");
  }
  else
  {
    cat("I'm sorry, I did not understand what you said.  Please try again.
  }
}
```

day	"weekend"
weather	"cloudy"

```
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/inputs.R')
Is this a weekday or weekend? weekday
Is it rainy or sunny? sunny
Sit at work and cry!!
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/inputs.R')
Is this a weekday or weekend? Friday
Is it rainy or sunny? sunny
I'm sorry, I did not understand what you said.  Please try again.
> source('C:/Users/belinsky/OneDrive/QFC/New R Class/R Root/inputs.R')
Is this a weekday or weekend? weekend
Is it rainy or sunny? cloudy
I'm sorry, I did not understand what you said.  Please try again.
> |
```

*Fig 8: Adding an error condition (**else**) to an **if-else-if** structure*

It is good programming practice in an ***if-else-if*** structure to create an error statement (*Fig 8*) that executes when all other conditions are checked and returns ***FALSE***.

8 - Application

A) Have a user enter values for:

1) The age of a fish
2) The weight of the fish
3) The location that the fish was caught (north or south)
4) The gender of the fish

B) Give a message if the fish is between 5 and 8 years old.

C) Give a message if the fish weighs between 50 and 150 grams.

D) Give a message for each of the four possible gender/port conditions (male & female, north and south) and add an error case for values that don't match any of the conditions.

E) Challenge: Give a message if the fish weighs between 20 and 100 grams and comes from either the north or south port.

9 - Extension: The or (||) operator on the keyboard

The ***or*** symbol (||) is made up of two "pipe characters" (|). On most keyboards, the pipe character (|) is on the same key as the backslash (\ ) and right above the ***Enter*** (*Fig 9*. Sometimes the pipe symbol will be broken like this: ¦

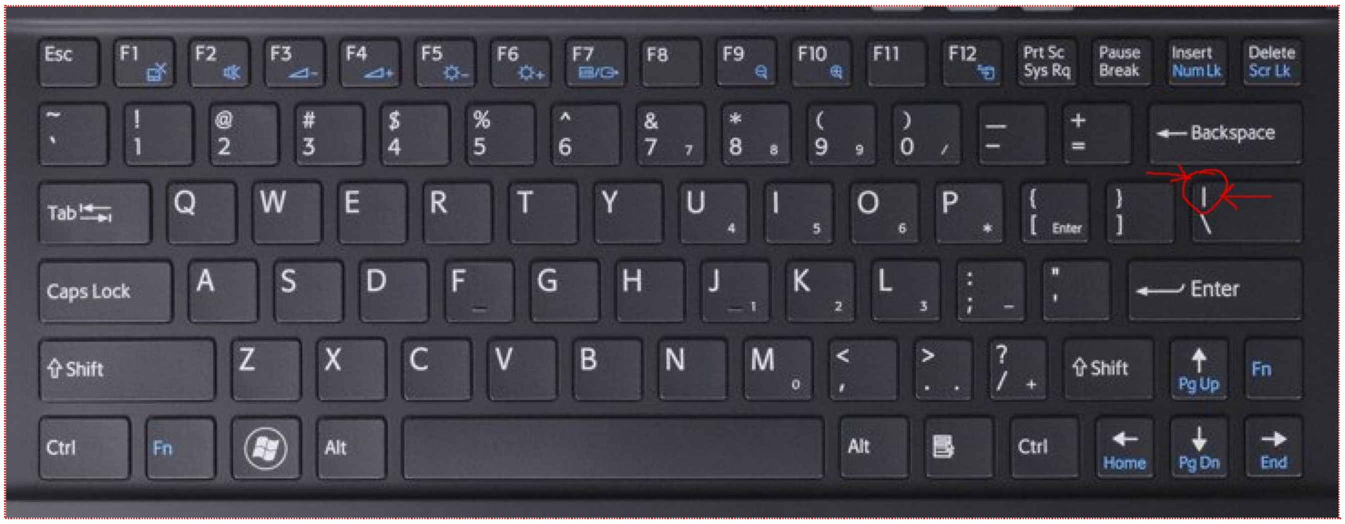


Fig 9: Keyboard - placement of pipe character

10 - Trap: All conditional statements must be explicit

When we are verbalizing conditional statements we often skip variable names if they have already been used for instance:

- If the fish's age is 2 or 3
- If your favorite animal is a llama or an alpaca

Because of this, it is intuitive to make the corresponding conditional statements:

- if (fishAge == 2 || 3)
- if (favAnimal == "llama" || "alpaca")

But in scripting every conditional statement must be explicit -- in other words all conditions need a variable and a value. In English this would be:

- If the fish's age is 2 or the fish's age is 3
- If the favorite animal is a llama or the favorite animal is an alpaca

And in script these conditional statements are:

- if (fishAge == 2 || fishAge == 3)
- if (favAnimal == "llama" || favAnimal == "alpaca")

10.1 - Why the conditions must be explicit

The following statements:

- if (fishAge == 2 || 3)
- if (favAnimal == "llama" || "alpaca")

Are effectively making the statements:

- if (fishAge == 2) ***or*** if(3)
- if (favAnimal == "llama") ***or*** if("alpaca")

if("alpaca"***)*** will cause an error because string values cannot be translated by R into a logical value (i.e., ***TRUE*** or ***FALSE***)

However, *R can translate all numeric values into a logical value*. In fact, all numeric values except **0**, get translated to ***TRUE*** and **0** gets translated as ***FALSE***.

So, ***3***, when used in a conditional statement is ***TRUE***, meaning **if(**fishAge == 2 || 3**)** is ***TRUE*** no matter what the value of ***fishAge*** is.

11 - Extension: The single character logical operators: and (&) or (|)

You will often see the operators ***&*** and */* used in place of ***&&*** and *//*. For all the examples we have done so far, the single logical operators (***&,*** */*) are functionally equivalent to the double logical operators (***&&,*** *//*). This is because we have only looked at variables with one value. The functionality between the single and double logical operator change when we start dealing with *variables that have multiple values* (called *vectors*). We will talk more about this when we introduce vectors. Essentially, single logical operators look at individual values in vectors whereas double operators look at the whole vector.