STOR 320 Joins

Lecture 10

Yao Li

Department of Statistics and Operations Research

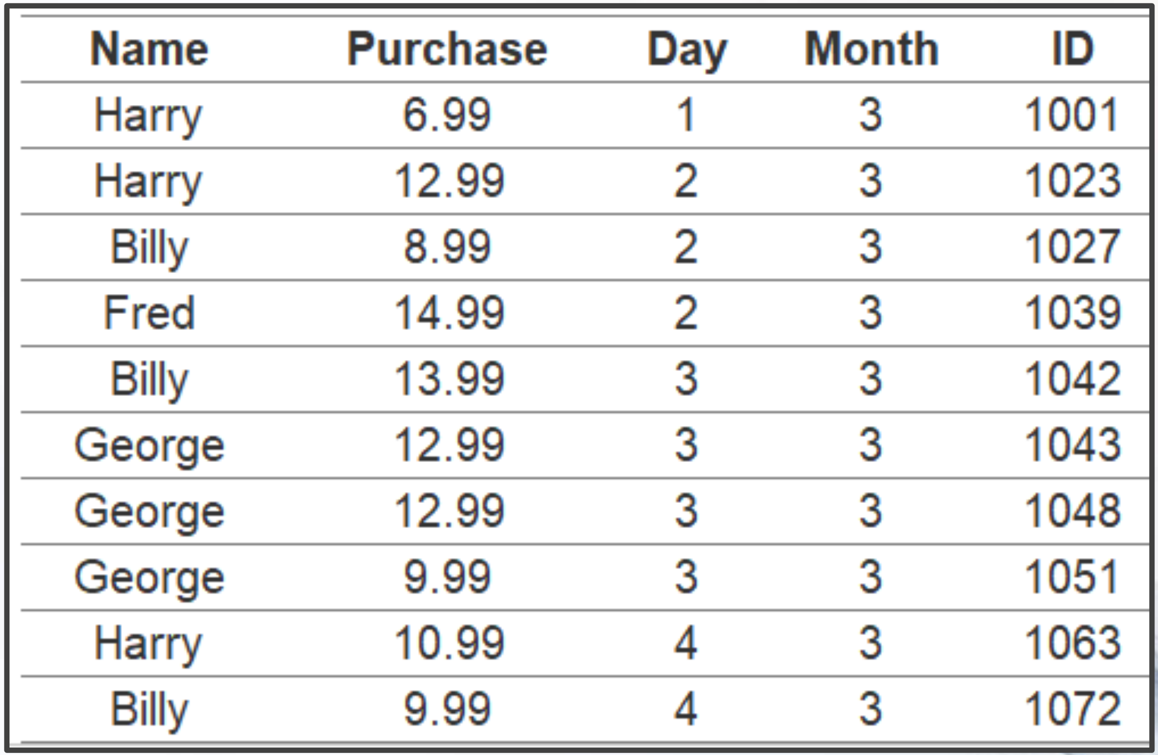
UNC Chapel Hill

Introduction to Joins

- Read Chapter 10
- Usually, Multiple Tables of Data are Used in Analysis
- Data Must Be Merged Prior to Analysis
- Requires Attention to Detail
- Fundamental Concept in Data Science

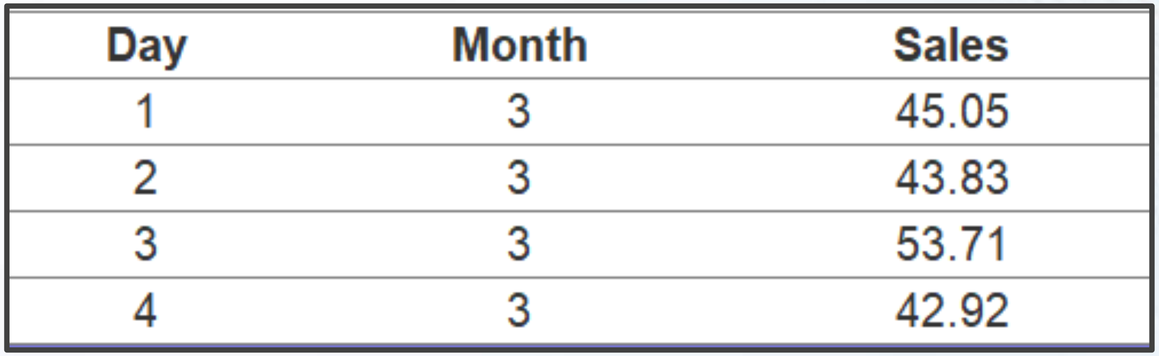
Sample Data

- Transaction Data



Name	Purchase	Day	Month	ID
Harry	6.99	1	3	1001
Harry	12.99	2	3	1023
Billy	8.99	2	3	1027
Fred	14.99	2	3	1039
Billy	13.99	3	3	1042
George	12.99	3	3	1043
George	12.99	3	3	1048
George	9.99	3	3	1051
Harry	10.99	4	3	1063
Billy	9.99	4	3	1072

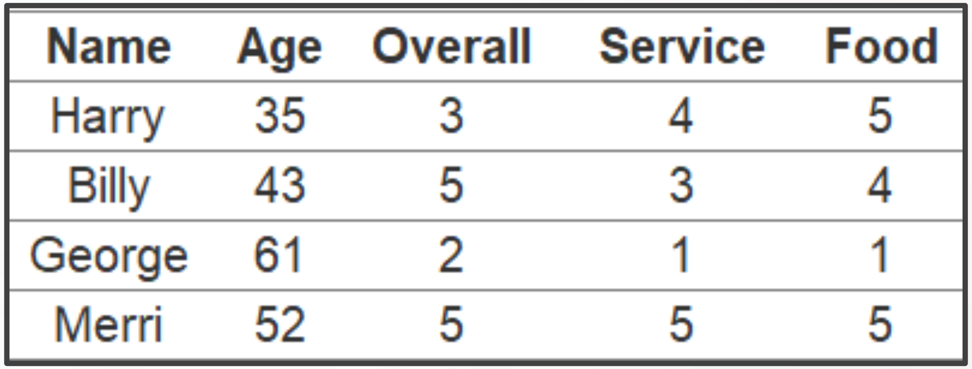
- Sales Data



Day	Month	Sales
1	3	45.05
2	3	43.83
3	3	53.71
4	3	42.92

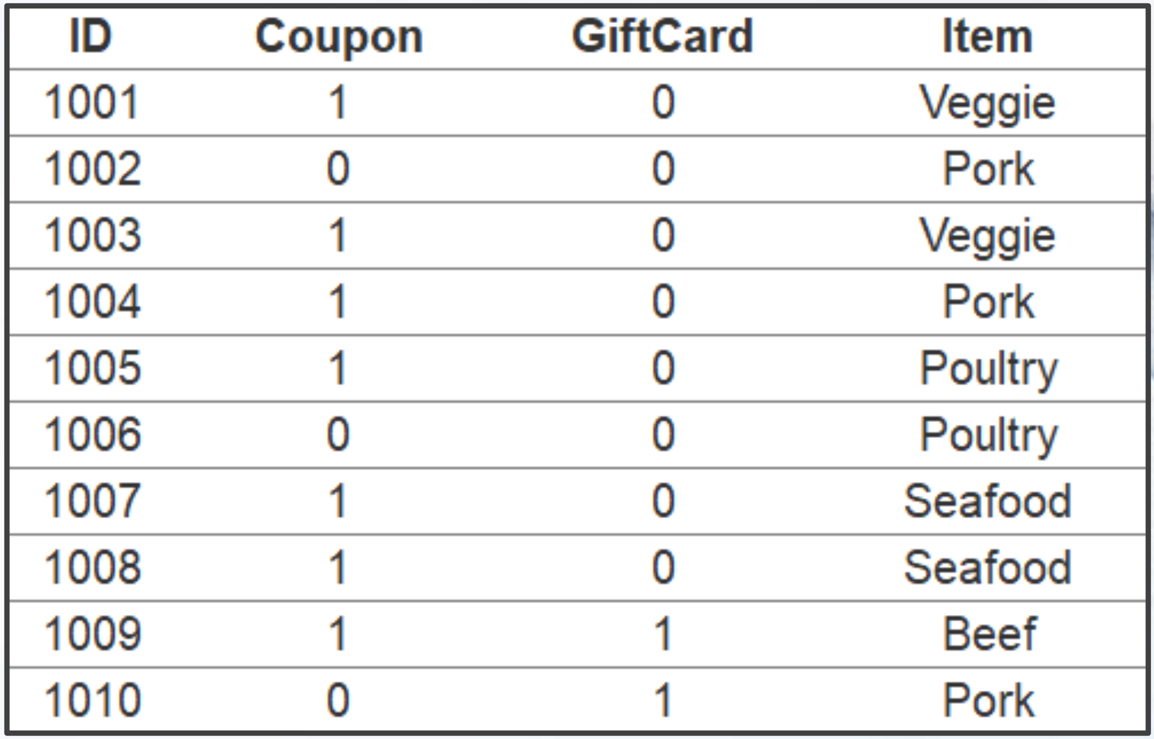
Sample Data

- Survey Data



Name	Age	Overall	Service	Food
Harry	35	3	4	5
Billy	43	5	3	4
George	61	2	1	1
Merri	52	5	5	5

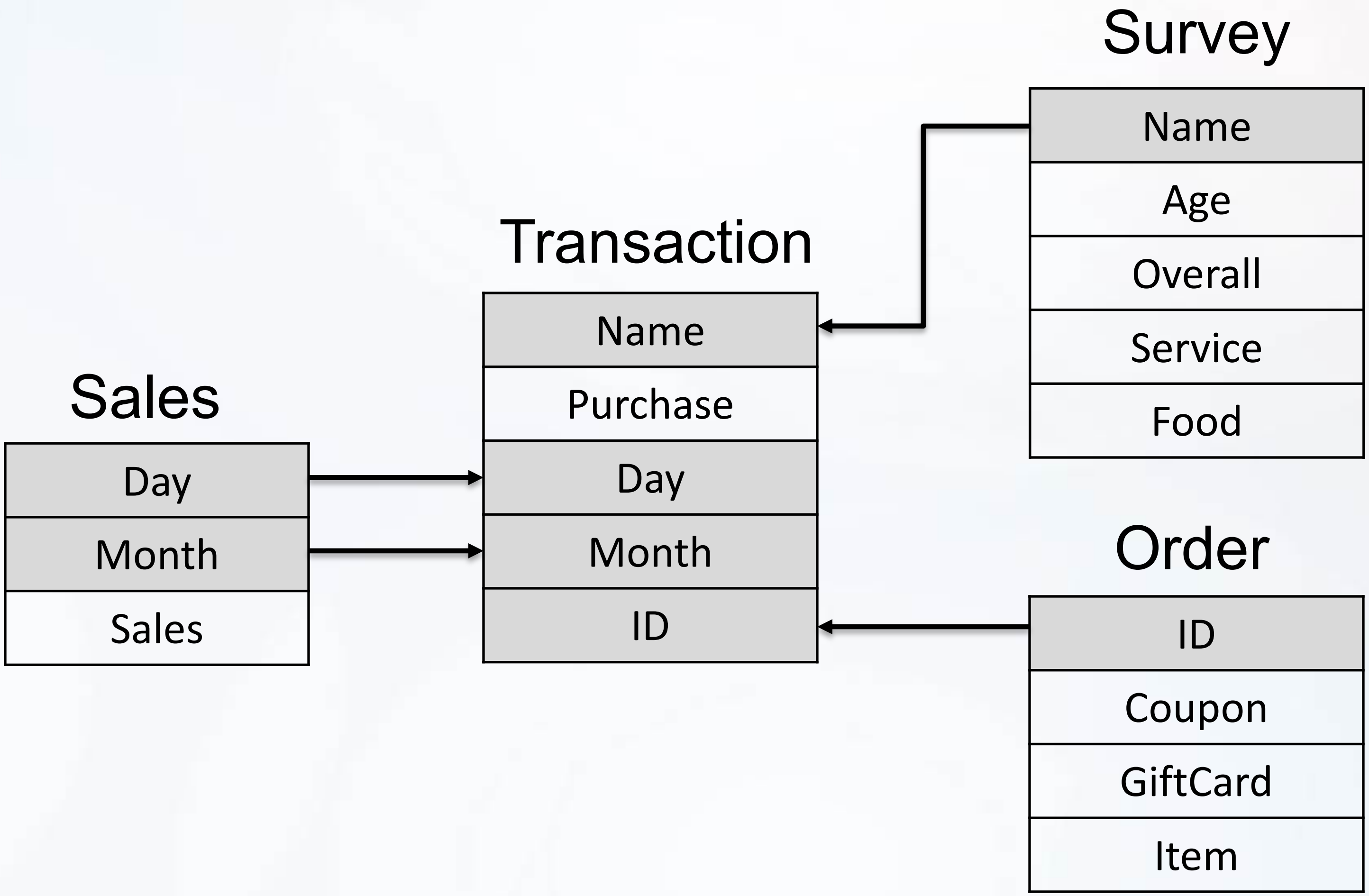
- Order Data (Preview)



ID	Coupon	GiftCard	Item
1001	1	0	Veggie
1002	0	0	Pork
1003	1	0	Veggie
1004	1	0	Pork
1005	1	0	Poultry
1006	0	0	Poultry
1007	1	0	Seafood
1008	1	0	Seafood
1009	1	1	Beef
1010	0	1	Pork

Sample Data: Why Join?

- Scenario: Restaurant Owner
- What Questions Can We Answer?
- What Insights Might We Learn?
- Why Connect the Data?



Survey

- Name
- Age
- Overall
- Service
- Food

Transaction

- Name
- Purchase
- Day
- Month
- ID

Sales

- Day
- Month
- Sales

Order

- ID
- Coupon
- GiftCard
- Item

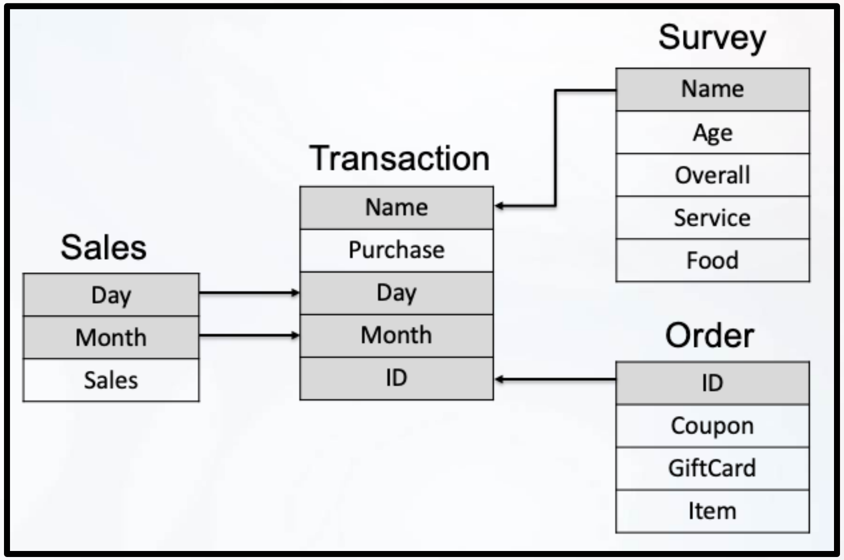
Keys

- The Variable(s) That Uniquely Identify an Observation

- Two Types:
  - Primary = Uniquely Identifies an Observation in Its Own Table
    - Order$ID

  - Foreign = Uniquely Identifies an Observation in Another Table
    - Transaction$Name

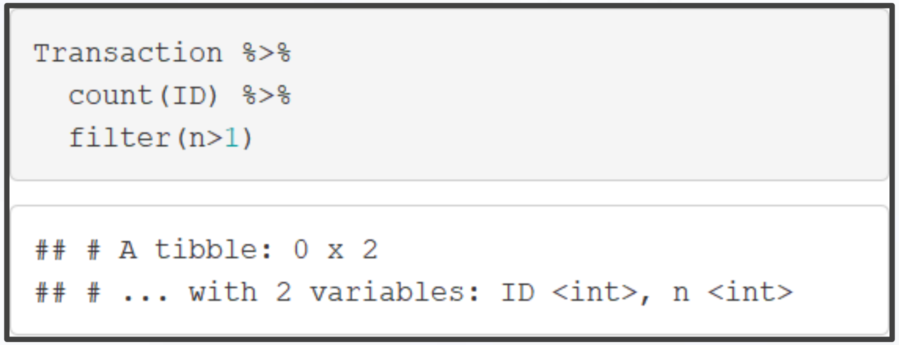
Keys: Sample Data



- Identifying the Primary Keys
  - ID is a Primary Key for Both Transaction and Order Data
  - Day + Month is a Primary Key for Sales Data
  - Name is a Primary Key for Survey Data

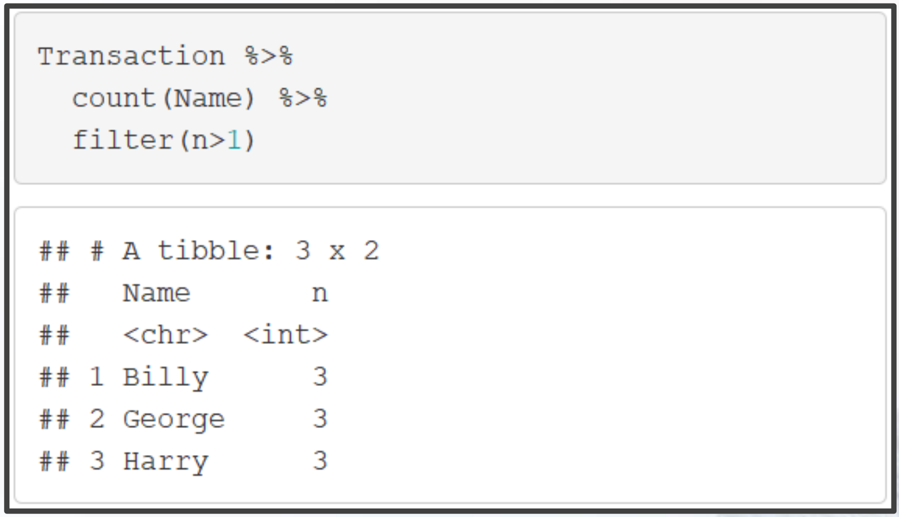
Keys: Verification

- Verifying the Primary Keys



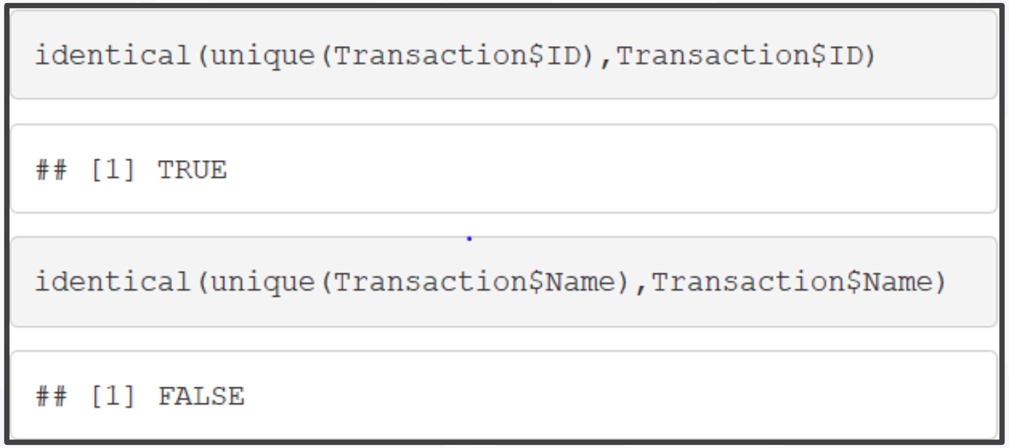
```
Transaction %>%
  count(ID) %>%
  filter(n>1)
```

```
## # A tibble: 0 x 2
## # ... with 2 variables: ID <int>, n <int>
```



```
Transaction %>%
  count(Name) %>%
  filter(n>1)
```

```
## # A tibble: 3 x 2
##   Name       n
##   <chr>  <int>
## 1 Billy      3
## 2 George     3
## 3 Harry      3
```



```
identical(unique(Transaction$ID),Transaction$ID)
```

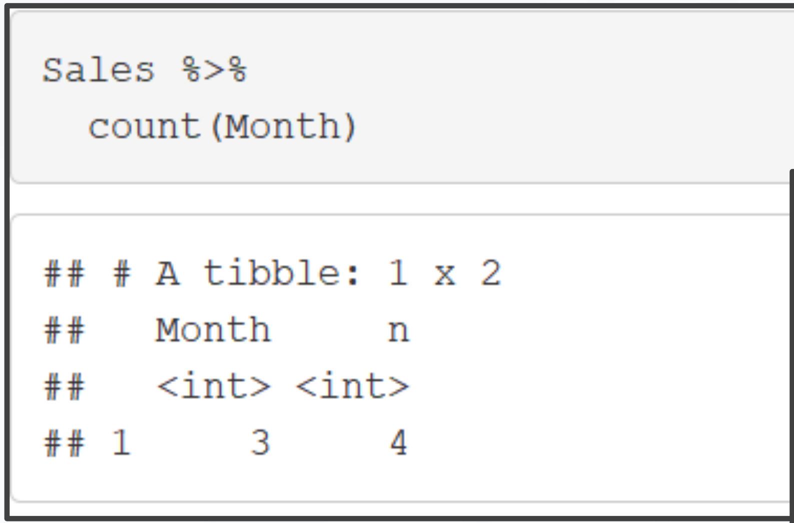
```
## [1] TRUE
```

```
identical(unique(Transaction$Name),Transaction$Name)
```

```
## [1] FALSE
```

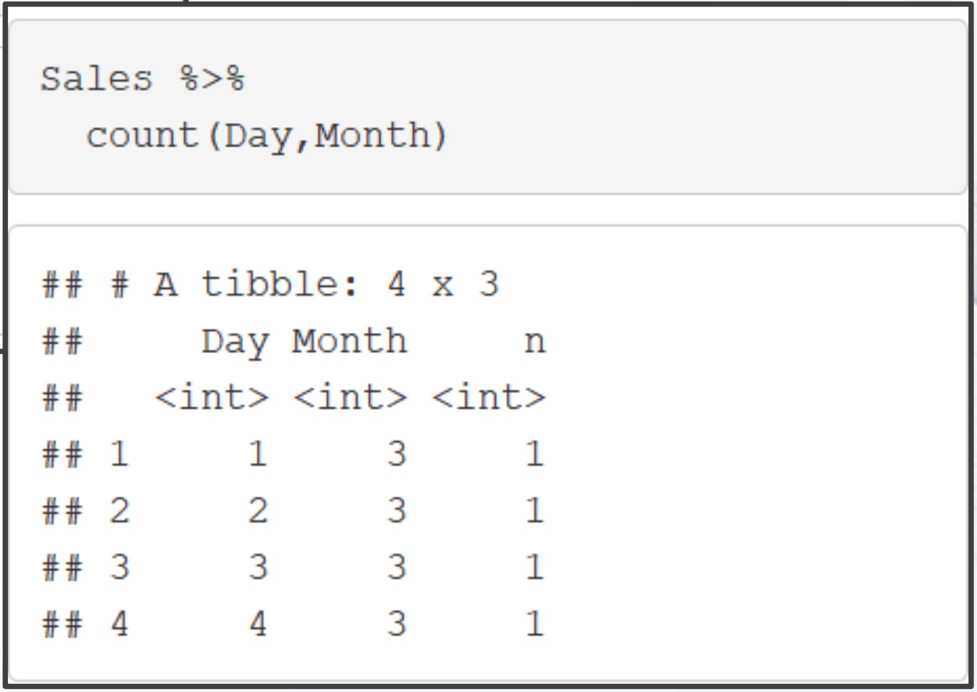
Keys: Verification

- Verifying the Primary Keys



```
Sales %>%
  count(Month)
```

```
## # A tibble: 1 x 2
##   Month     n
##   <int> <int>
## 1     3     4
```

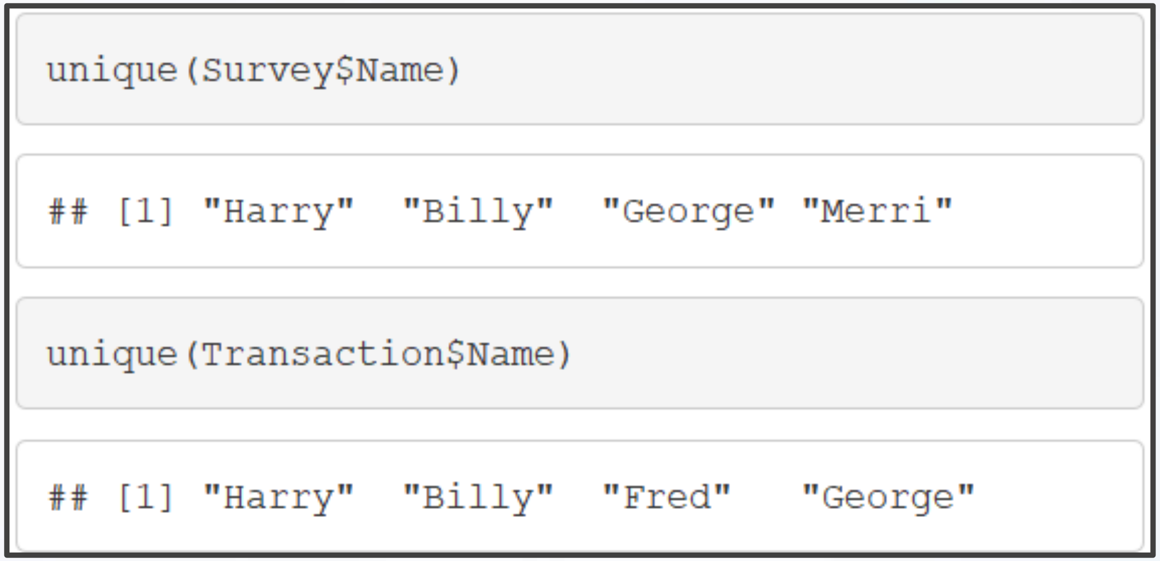


```
Sales %>%
  count(Day,Month)
```

```
## # A tibble: 4 x 3
##       Day Month     n
##     <int> <int> <int>
## 1       1     3     1
## 2       2     3     1
## 3       3     3     1
## 4       4     3     1
```

Mutating Joins: Inner Joins

- Inner Joins
  - Matches Observations When Their Keys are Equal
  - Example: Survey + Transaction



```
unique(Survey$Name)
```

```
## [1] "Harry"  "Billy"  "George" "Merri"
```

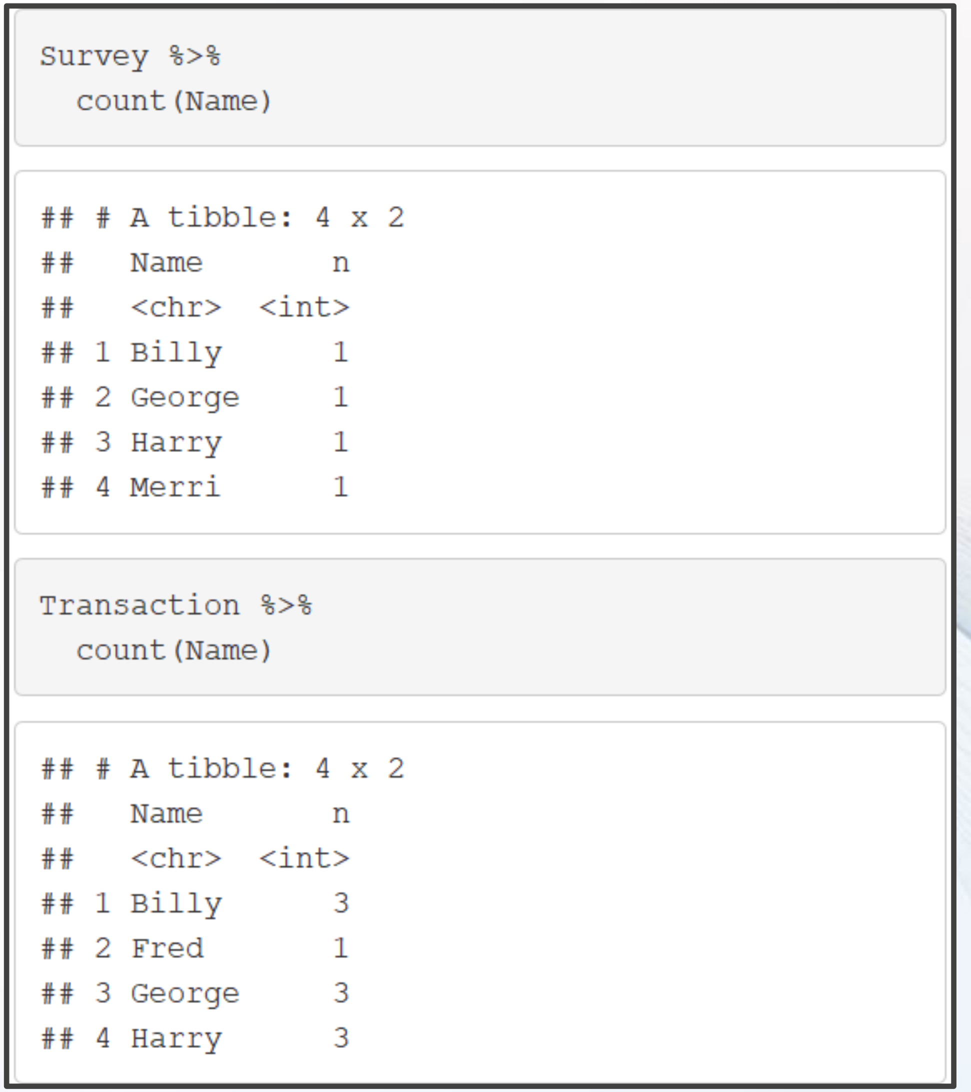
```
unique(Transaction$Name)
```

```
## [1] "Harry"  "Billy"  "Fred"   "George"
```

Mutating Joins: Inner Join

- Inner Joins

  - Example:
    Survey + Transaction



```
Survey %>%
  count(Name)
```

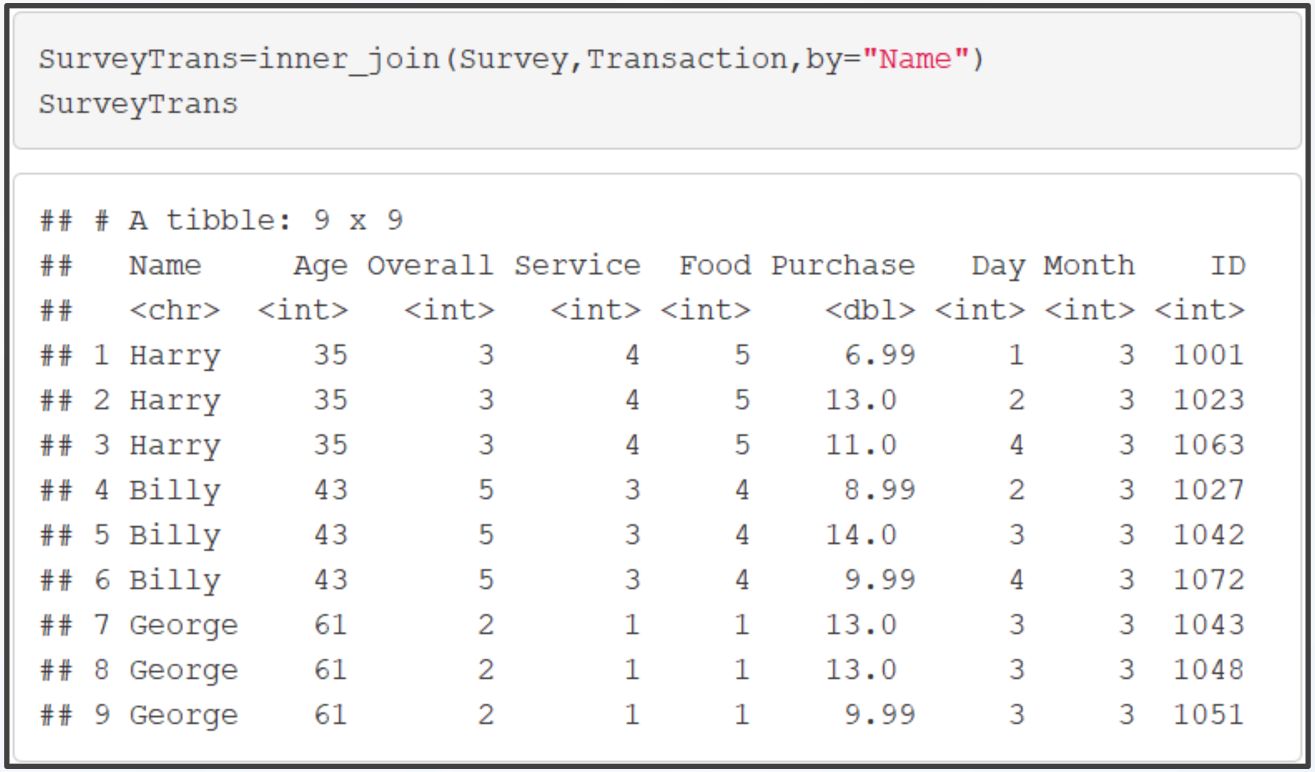
```
## # A tibble: 4 x 2
##   Name       n
##   <chr>  <int>
## 1 Billy      1
## 2 George     1
## 3 Harry      1
## 4 Merri      1
```

```
Transaction %>%
  count(Name)
```

```
## # A tibble: 4 x 2
##   Name       n
##   <chr>  <int>
## 1 Billy      3
## 2 Fred       1
## 3 George     3
## 4 Harry      3
```

Mutating Joins: Inner Join

- Inner Joins
  - Example: Survey + Transaction

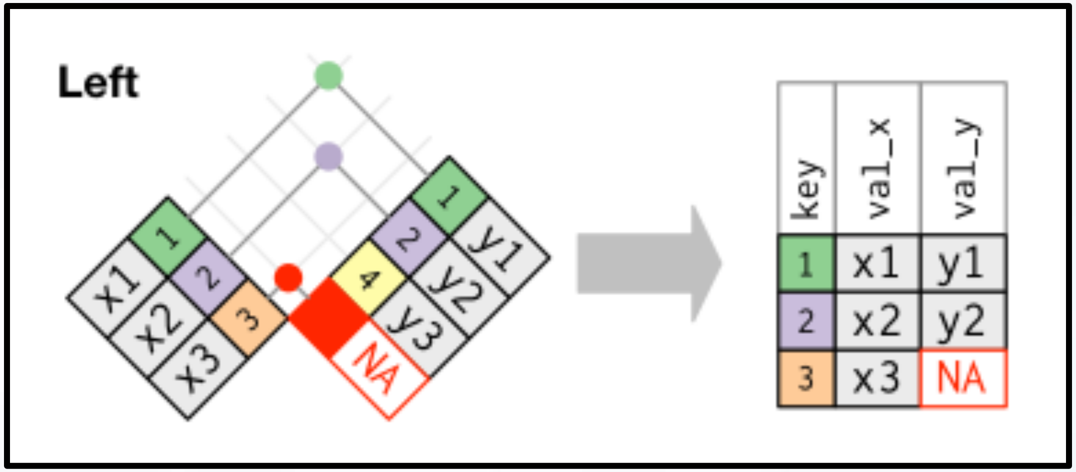


```
SurveyTrans=inner_join(Survey,Transaction,by="Name")
SurveyTrans
```

```
## # A tibble: 9 x 9
##   Name     Age Overall Service  Food Purchase   Day Month    ID
##   <chr>  <int>   <int>   <int> <int>    <dbl> <int> <int> <int>
## 1 Harry     35       3       4     5     6.99     1     3  1001
## 2 Harry     35       3       4     5    13.0      2     3  1023
## 3 Harry     35       3       4     5    11.0      4     3  1063
## 4 Billy     43       5       3     4     8.99     2     3  1027
## 5 Billy     43       5       3     4    14.0      3     3  1042
## 6 Billy     43       5       3     4     9.99     4     3  1072
## 7 George    61       2       1     1    13.0      3     3  1043
## 8 George    61       2       1     1    13.0      3     3  1048
## 9 George    61       2       1     1     9.99     3     3  1051
```

Mutating Joins: Left Join

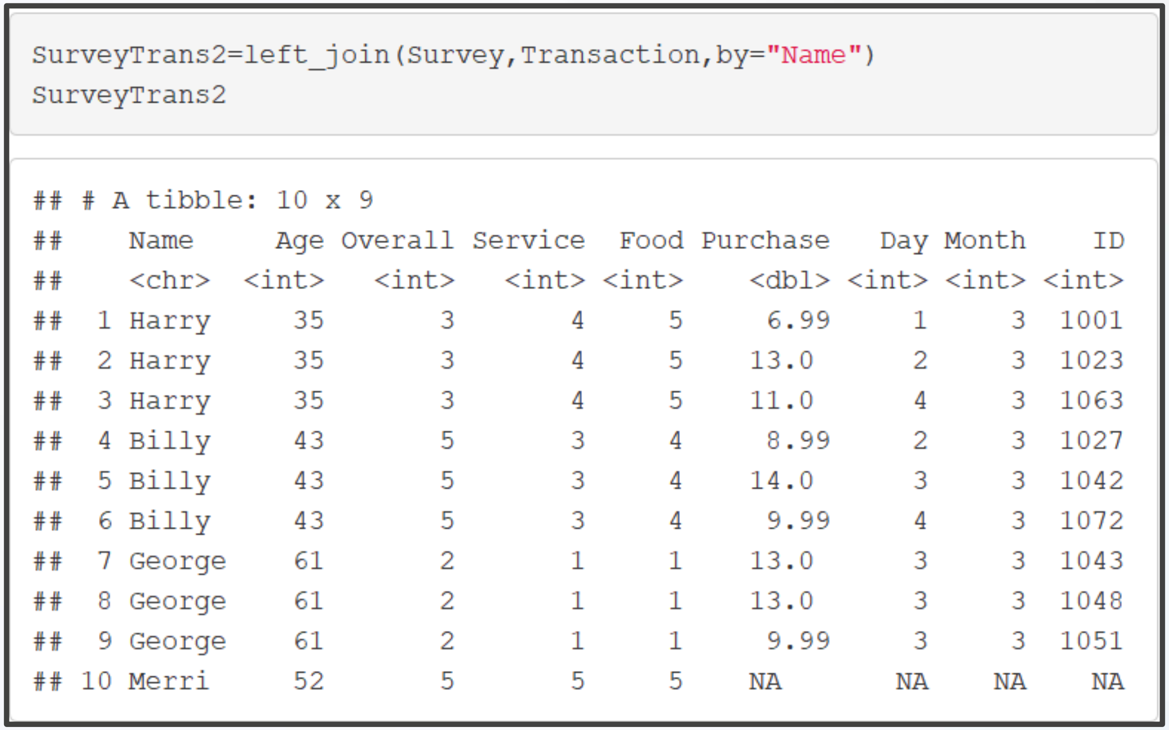
- Outer Joins
  - Left-Join
    - Keeps All Observations in Left Dataset



key	val_x	val_y
1	x1	y1
2	x2	y2
3	x3	NA

Mutating Joins: Left Join

- Outer Joins
  - Left-Join
    - Example: Survey + Trans.

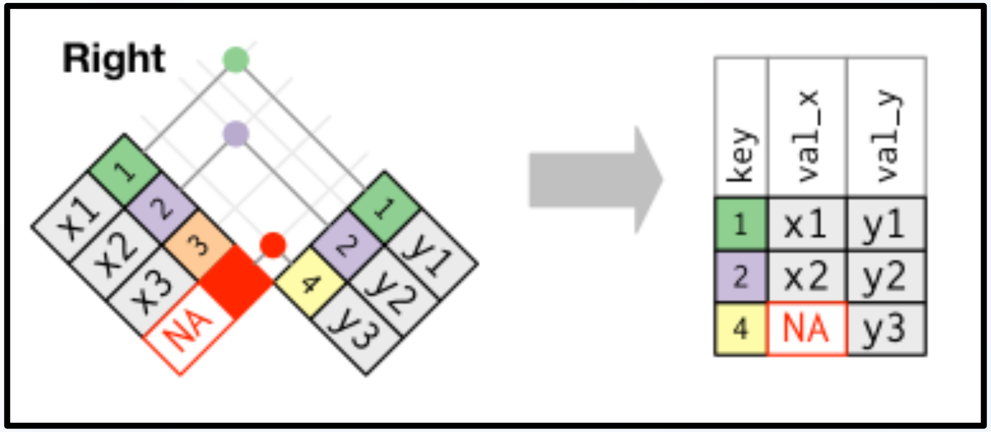


```
SurveyTrans2=left_join(Survey,Transaction,by="Name")
SurveyTrans2
```

```
## # A tibble: 10 x 9
##    Name     Age Overall Service  Food Purchase   Day Month    ID
##    <chr>  <int>   <int>   <int> <int>    <dbl> <int> <int> <int>
##  1 Harry     35       3       4     5     6.99     1     3  1001
##  2 Harry     35       3       4     5    13.0      2     3  1023
##  3 Harry     35       3       4     5    11.0      4     3  1063
##  4 Billy     43       5       3     4     8.99     2     3  1027
##  5 Billy     43       5       3     4    14.0      3     3  1042
##  6 Billy     43       5       3     4     9.99     4     3  1072
##  7 George    61       2       1     1    13.0      3     3  1043
##  8 George    61       2       1     1    13.0      3     3  1048
##  9 George    61       2       1     1     9.99     3     3  1051
## 10 Merri     52       5       5     5    NA       NA    NA    NA
```

Mutating Joins: Right Join

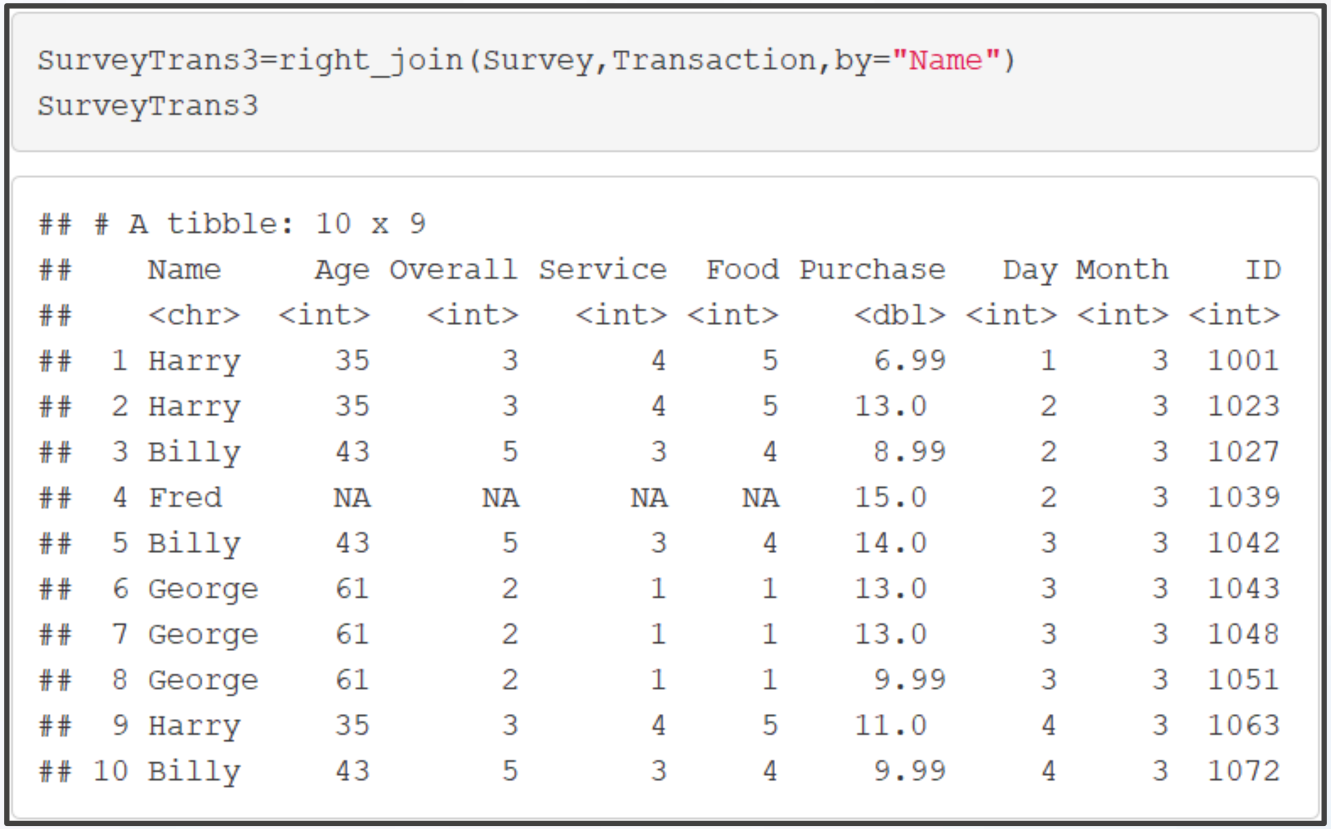
- Outer Joins
  - Right-Join
    - Keeps All Observations in Right Dataset



key	val_x	val_y
1	x1	y1
2	x2	y2
4	NA	y3

Mutating Joins: Right Join

- Outer Joins
  - Right-Join
    - Example: Survey + Trans.

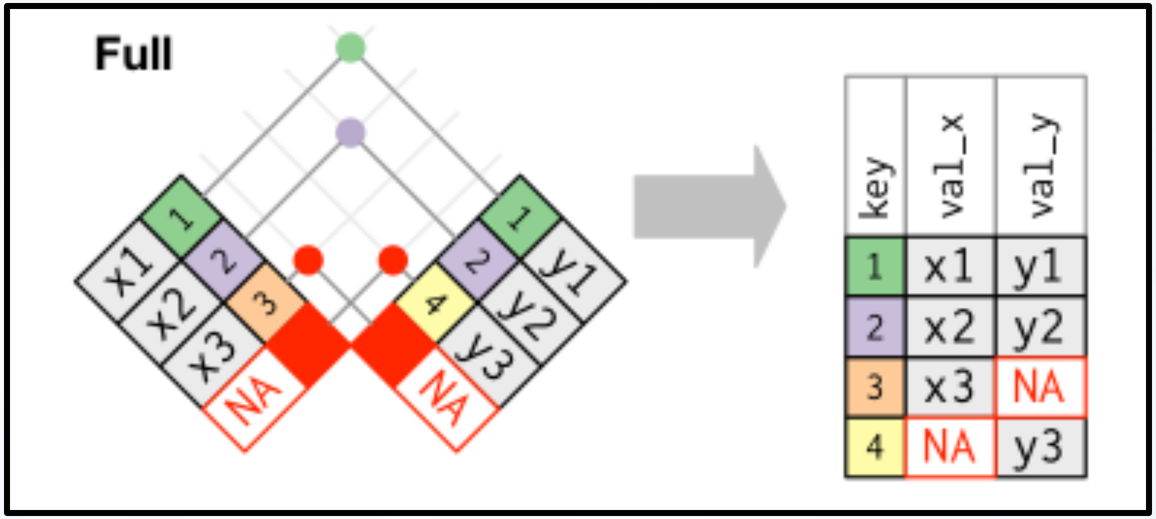


```
SurveyTrans3=right_join(Survey,Transaction,by="Name")
SurveyTrans3
```

```
## # A tibble: 10 x 9
##    Name     Age Overall Service  Food Purchase   Day Month    ID
##    <chr>  <int>   <int>   <int> <int>    <dbl> <int> <int> <int>
##  1 Harry     35       3       4     5     6.99     1     3  1001
##  2 Harry     35       3       4     5    13.0      2     3  1023
##  3 Billy     43       5       3     4     8.99     2     3  1027
##  4 Fred      NA      NA      NA    NA    15.0      2     3  1039
##  5 Billy     43       5       3     4    14.0      3     3  1042
##  6 George    61       2       1     1    13.0      3     3  1043
##  7 George    61       2       1     1    13.0      3     3  1048
##  8 George    61       2       1     1     9.99     3     3  1051
##  9 Harry     35       3       4     5    11.0      4     3  1063
## 10 Billy     43       5       3     4     9.99     4     3  1072
```

Mutating Joins: Full Join

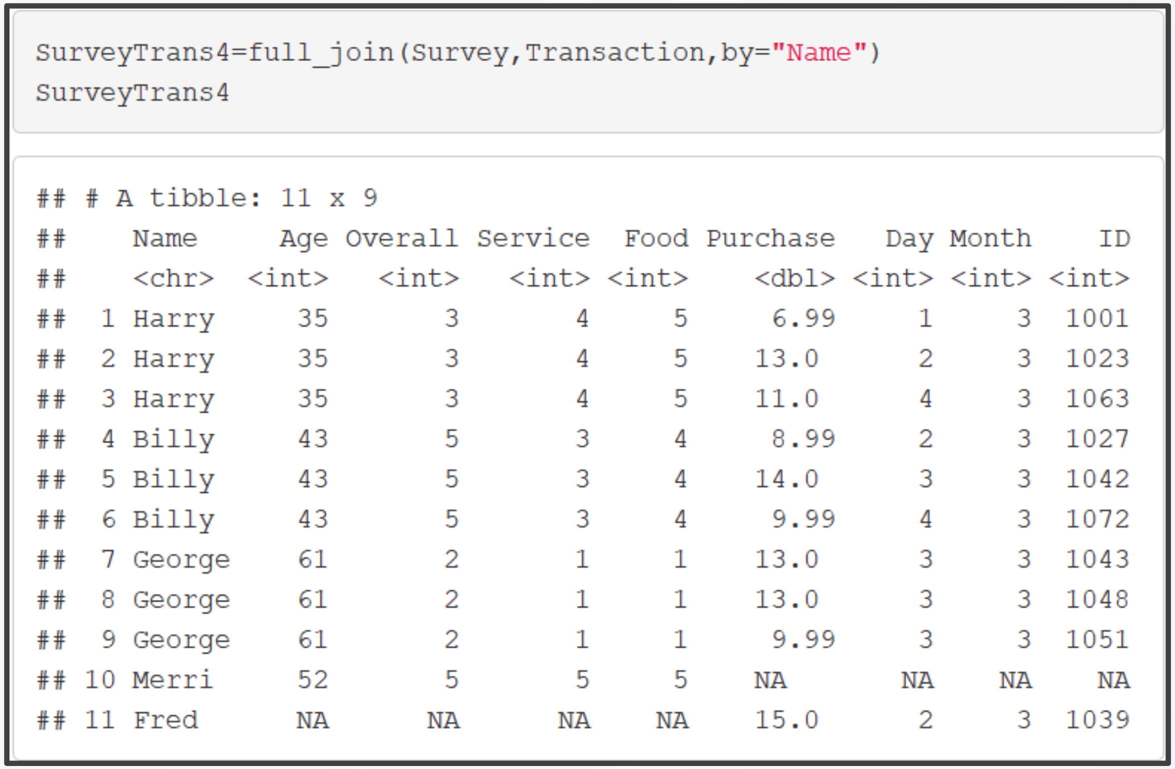
- Outer Joins
  - Full-Join
    - Keeps All Observations in Both Datasets



key	val_x	val_y
1	x1	y1
2	x2	y2
3	x3	NA
4	NA	y3

Mutating Joins: Full Join

- Outer Joins
  - Full-Join
    - Example: Survey + Trans.

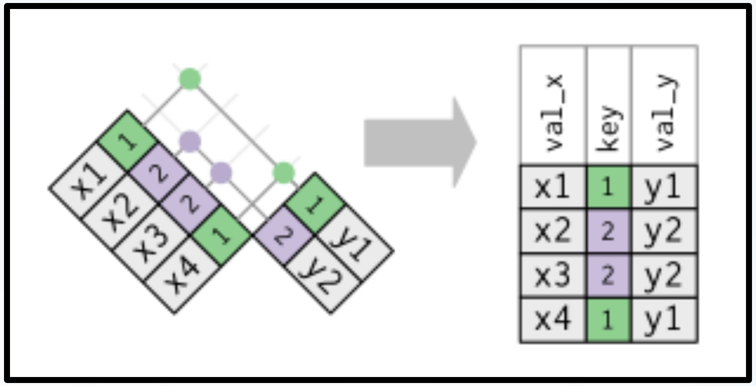


```
SurveyTrans4=full_join(Survey,Transaction,by="Name")
SurveyTrans4
```

```
## # A tibble: 11 x 9
##    Name     Age Overall Service  Food Purchase   Day Month    ID
##    <chr>  <int>   <int>   <int> <int>    <dbl> <int> <int> <int>
##  1 Harry     35       3       4     5     6.99     1     3  1001
##  2 Harry     35       3       4     5    13.0      2     3  1023
##  3 Harry     35       3       4     5    11.0      4     3  1063
##  4 Billy     43       5       3     4     8.99     2     3  1027
##  5 Billy     43       5       3     4    14.0      3     3  1042
##  6 Billy     43       5       3     4     9.99     4     3  1072
##  7 George    61       2       1     1    13.0      3     3  1043
##  8 George    61       2       1     1    13.0      3     3  1048
##  9 George    61       2       1     1     9.99     3     3  1051
## 10 Merri     52       5       5     5    NA       NA    NA    NA
## 11 Fred      NA      NA      NA    NA    15.0      2     3  1039
```

Duplicate Keys

- 1. One to Many Relationship:
  - All Examples Illustrate the Scenario When Keys Repeat

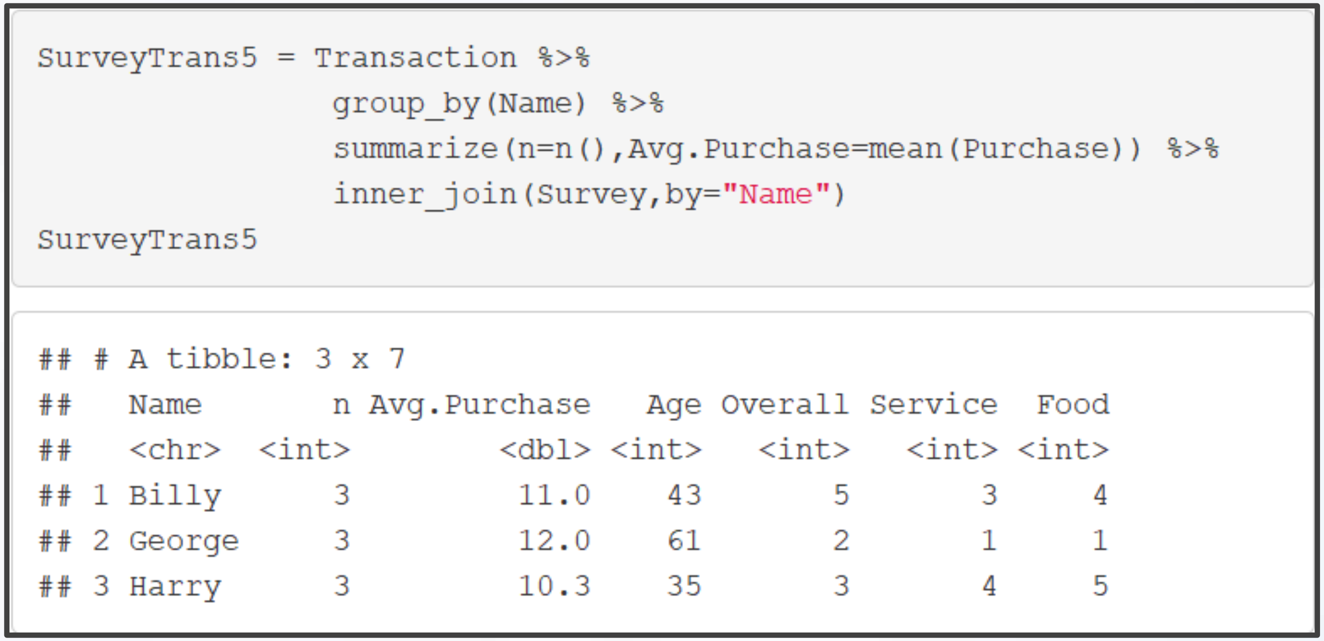


val_x	key	val_y
x1	1	y1
x2	2	y2
x3	2	y2
x4	1	y1

- 2. Many to Many “Usually” Indicates Error
- Identify Your Most Important Dataset.
- Summarize then Merge

Summarize then Join

- Duplicate Keys
  - Example

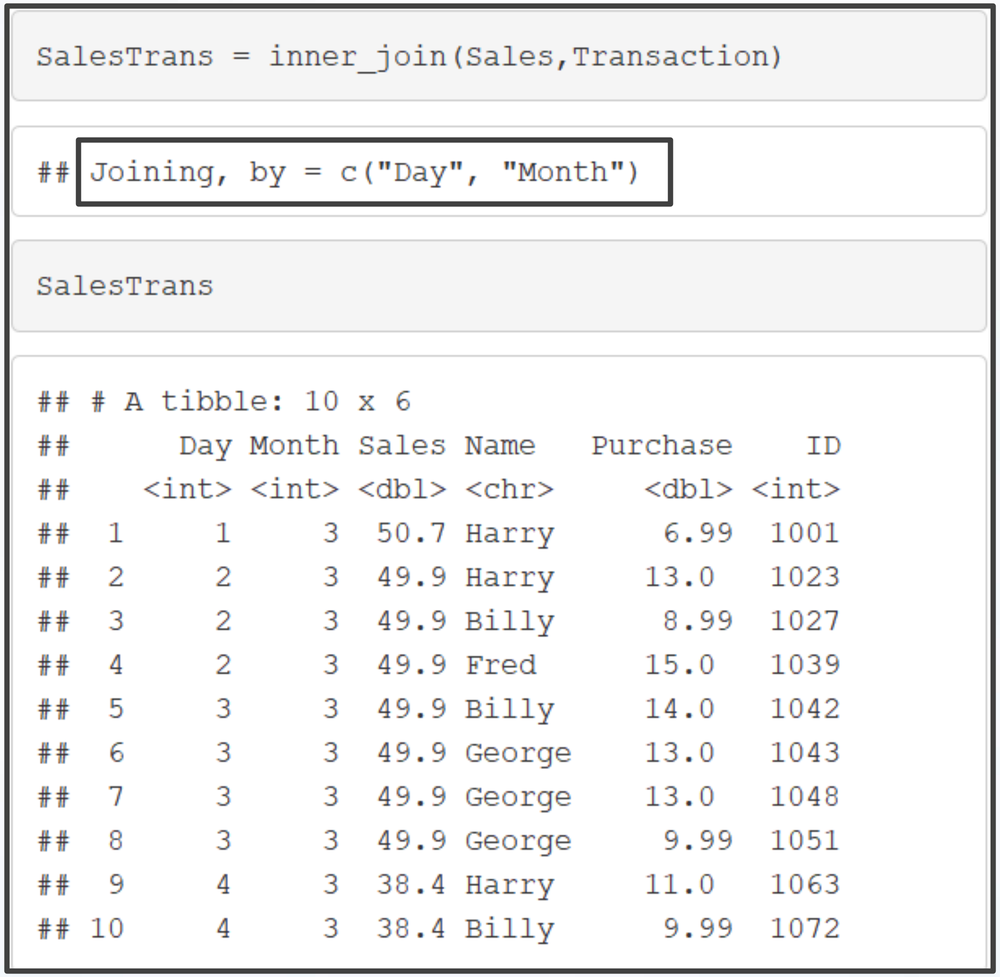


```
SurveyTrans5 = Transaction %>%
                group_by(Name) %>%
                summarize(n=n(),Avg.Purchase=mean(Purchase)) %>%
                inner_join(Survey,by="Name")
SurveyTrans5
```

```
## # A tibble: 3 x 7
##   Name       n Avg.Purchase   Age Overall Service  Food
##   <chr>  <int>        <dbl> <int>   <int>   <int> <int>
## 1 Billy      3         11.0    43       5       3     4
## 2 George     3         12.0    61       2       1     1
## 3 Harry      3         10.3    35       3       4     5
```

Defining the Key Columns

- Default: Uses All Variables that Appear in Both Tables



```
SalesTrans = inner_join(Sales,Transaction)
```

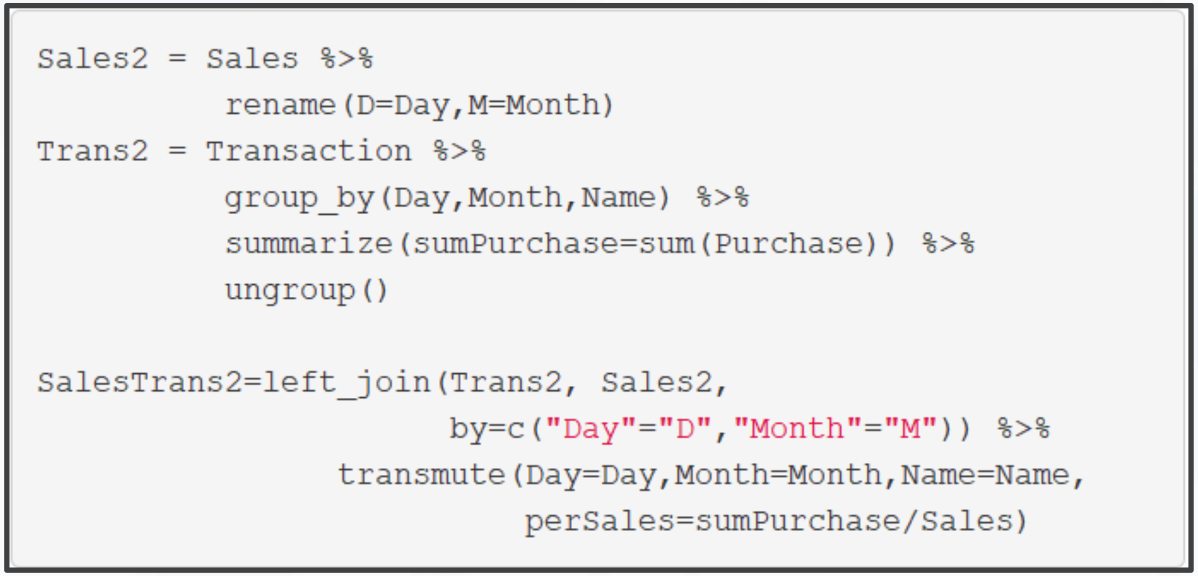
```
## Joining, by = c("Day", "Month")
```

```
SalesTrans
```

```
## # A tibble: 10 x 6
##       Day Month Sales Name    Purchase    ID
##     <int> <int> <dbl> <chr>      <dbl> <int>
##  1      1     3  50.7 Harry       6.99  1001
##  2      2     3  49.9 Harry      13.0   1023
##  3      2     3  49.9 Billy       8.99  1027
##  4      2     3  49.9 Fred       15.0   1039
##  5      3     3  49.9 Billy      14.0   1042
##  6      3     3  49.9 George     13.0   1043
##  7      3     3  49.9 George     13.0   1048
##  8      3     3  49.9 George      9.99  1051
##  9      4     3  38.4 Harry      11.0   1063
## 10      4     3  38.4 Billy       9.99  1072
```

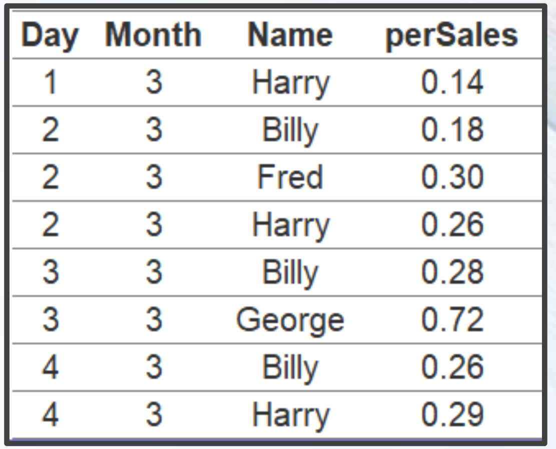
Defining the Key Columns

- Keys Based on Multiple Variables
- Key Names Can Be Different



```
Sales2 = Sales %>%
          rename(D=Day,M=Month)
Trans2 = Transaction %>%
          group_by(Day,Month,Name) %>%
          summarize(sumPurchase=sum(Purchase)) %>%
          ungroup()

SalesTrans2=left_join(Trans2, Sales2,
                      by=c("Day"="D","Month"="M")) %>%
                transmute(Day=Day,Month=Month,Name=Name,
                          perSales=sumPurchase/Sales)
```



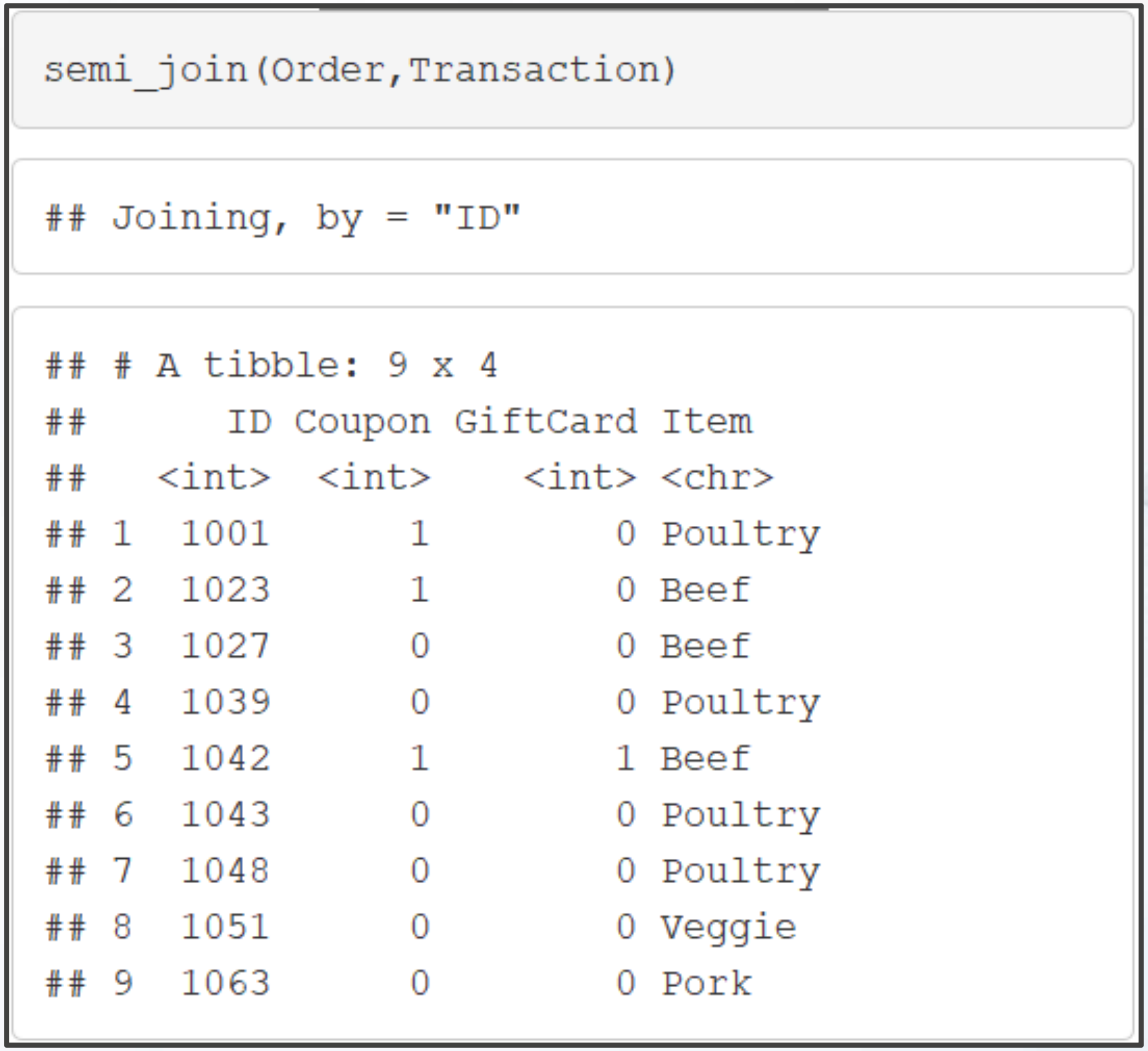
Day	Month	Name	perSales
1	3	Harry	0.14
2	3	Billy	0.18
2	3	Fred	0.30
2	3	Harry	0.26
3	3	Billy	0.28
3	3	George	0.72
4	3	Billy	0.26
4	3	Harry	0.29

Filtering Joins: Semi Join

- Semi-Join
  - `> semi_join(x,y)`
  - Keeps All Observations in Left Dataset That Have a Match in Right Dataset
  - Primary Data = Left
  - Scenario: Want All Order Data Only For Select Customers

Filtering Joins: Semi Join

- Semi-Join



```
semi_join(Order,Transaction)
```

```
## Joining, by = "ID"
```

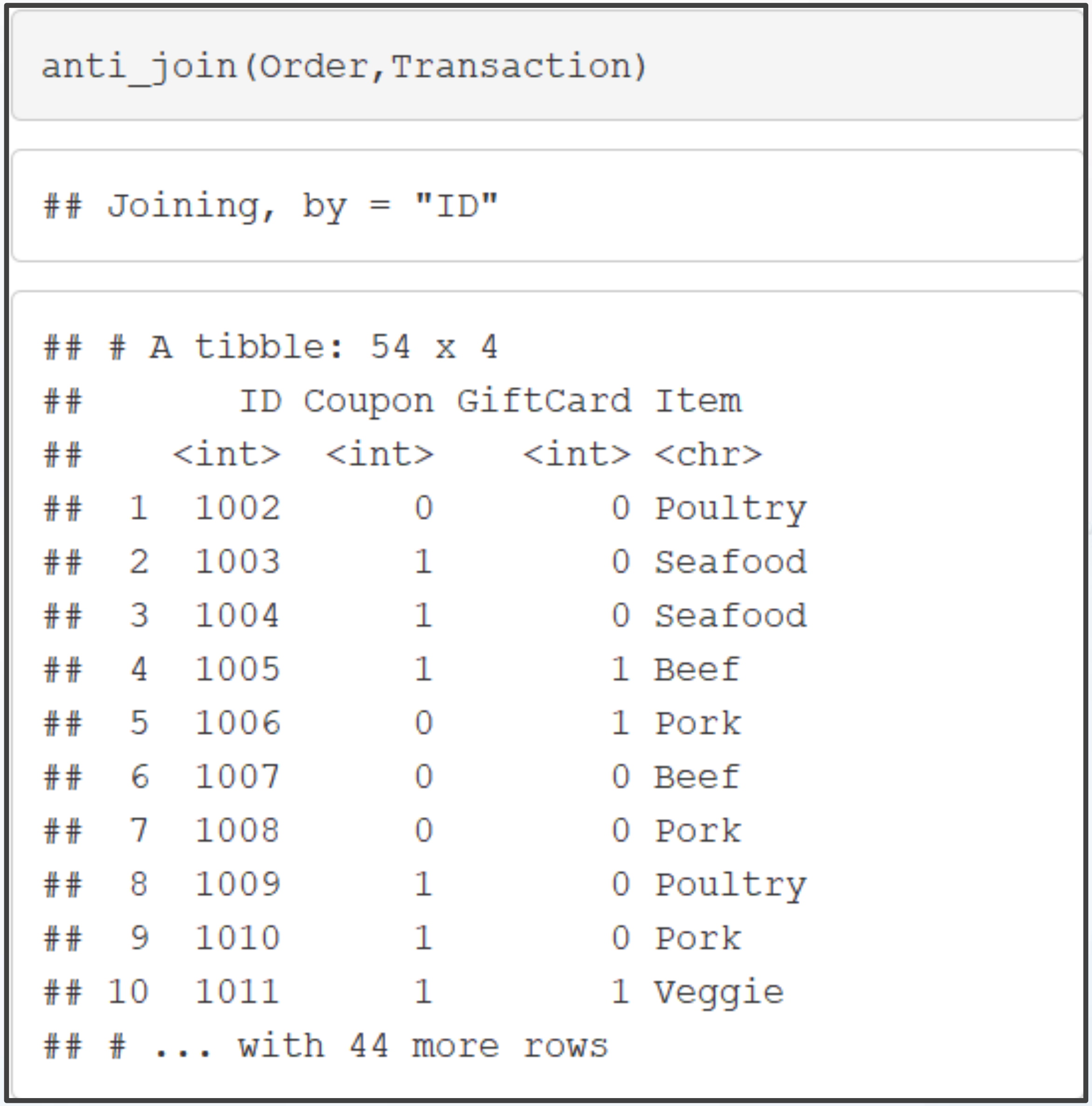
```
## # A tibble: 9 x 4
##        ID Coupon GiftCard Item
##     <int>  <int>    <int> <chr>
## 1  1001      1        0 Poultry
## 2  1023      1        0 Beef
## 3  1027      0        0 Beef
## 4  1039      0        0 Poultry
## 5  1042      1        1 Beef
## 6  1043      0        0 Poultry
## 7  1048      0        0 Poultry
## 8  1051      0        0 Veggie
## 9  1063      0        0 Pork
```

Filtering Joins: Anti Join

- Anti-Join
  - `> anti_join(x,y)`
  - Drops All Observations in Left Dataset That Have a Match in Right Dataset
  - Primary Data = Left
  - Scenario: Want All Order Data Except For Select Customers

Filtering Joins: Anti Join

- Anti-Join



```
anti_join(Order,Transaction)
```

```
## Joining, by = "ID"
```

```
## # A tibble: 54 x 4
##        ID Coupon GiftCard Item
##     <int>  <int>    <int> <chr>
##  1  1002      0        0 Poultry
##  2  1003      1        0 Seafood
##  3  1004      1        0 Seafood
##  4  1005      1        1 Beef
##  5  1006      0        1 Pork
##  6  1007      0        0 Beef
##  7  1008      0        0 Pork
##  8  1009      1        0 Poultry
##  9  1010      1        0 Pork
## 10  1011      1        1 Veggie
## # ... with 44 more rows
```

Joins Assignment

- Instructions
  - Download Analysis 2 Zip Folder
  - Unzip Folder
  - Open Analysis 2 Rmd File
  - Knit to HTML
  - Read Introduction

- Three Part Assignment
  - Each Part Self-Contained
  - Part 1: pivot_longer/pivot_wider
  - Part 2: Joins
  - Part 3: Web Scraping

Part 1: Cholesterol

- Closely Examine Datasets
  - Cholesterol
  - Cholesterol2

- Goals
  - Clean Datasets Separately
  - Merge According to According to Brand

- Things to Consider
  - Experimental Dataset is the “Main” Dataset
  - Requires Knowledge of How to Merge When Variable Names are Different

Part 2: Crime

- Goals
  - Attention to Detail
  - Merge All 5 Datasets
  - Practice with the Practical

- Things to Consider
  - Violent Crimes Data is the “Main” Dataset
  - Only Want Information for States Not Classified as Safe or Dangerous
  - Requires Cleaning
  - Repeatedly Use View Function

```
> ifelse(VAR==“OLD”, “NEW”, VAR)
```

Part 3: Wikipedia

- Goals
  - Search Through Wikipedia for a Table
  - Copy the URL to Rmd File
  - Describe Table
  - Scrape Table

- Things to Consider
  - Utilize Code from Web Scraping Tutorial
  - Run Code in Parts
  - Check Final Table to Make Sure It Worked