

STOR 320.1

Joins

Introduction to Joins

- Read Chapter 10 (13 on-line)
- 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

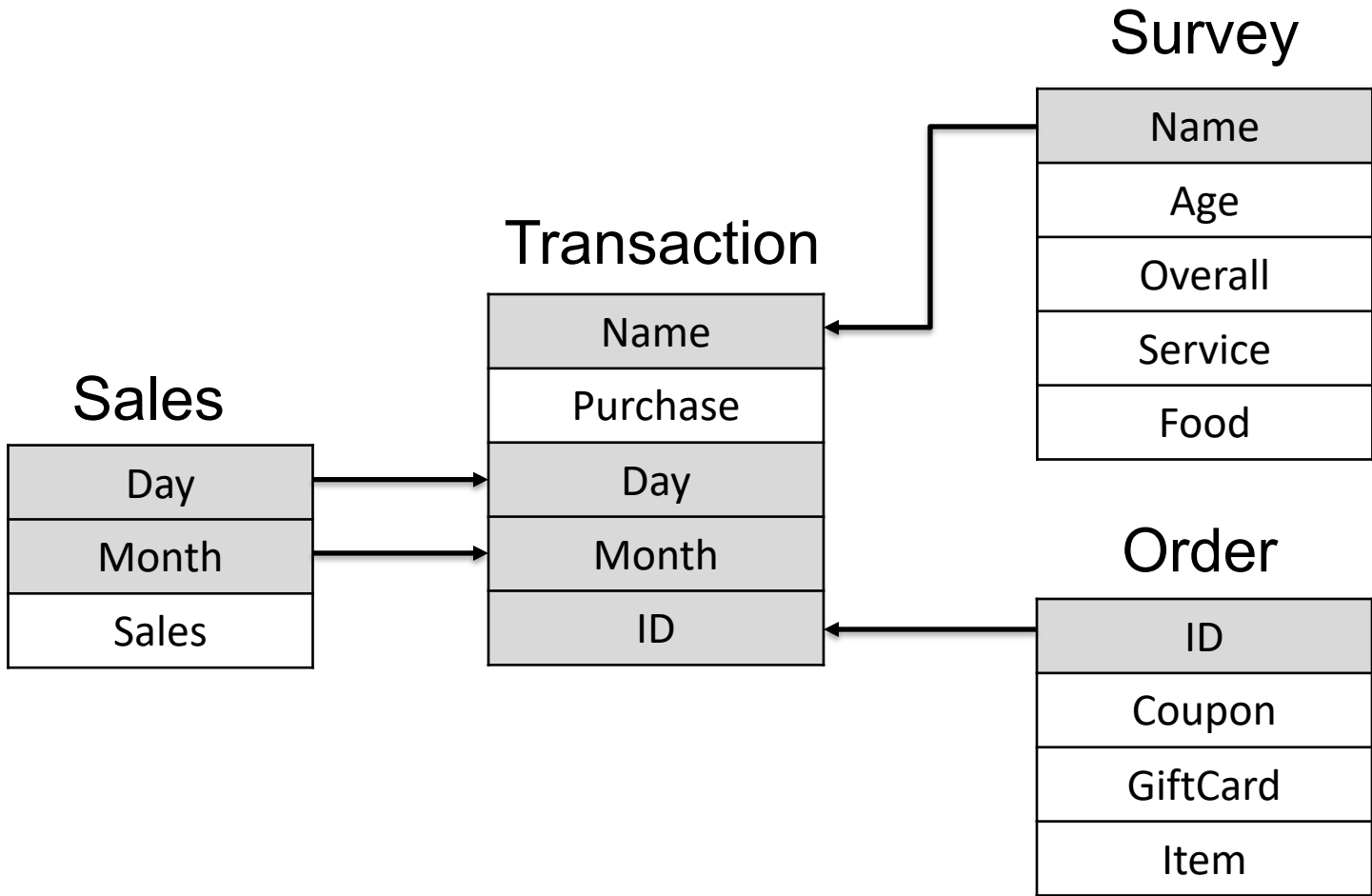
Name	Age	Overall	Service	Food
Harry	35	3	4	5
Billy	43	5	3	4
George	61	2	1	1
Merri	52	5	5	5

- 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?



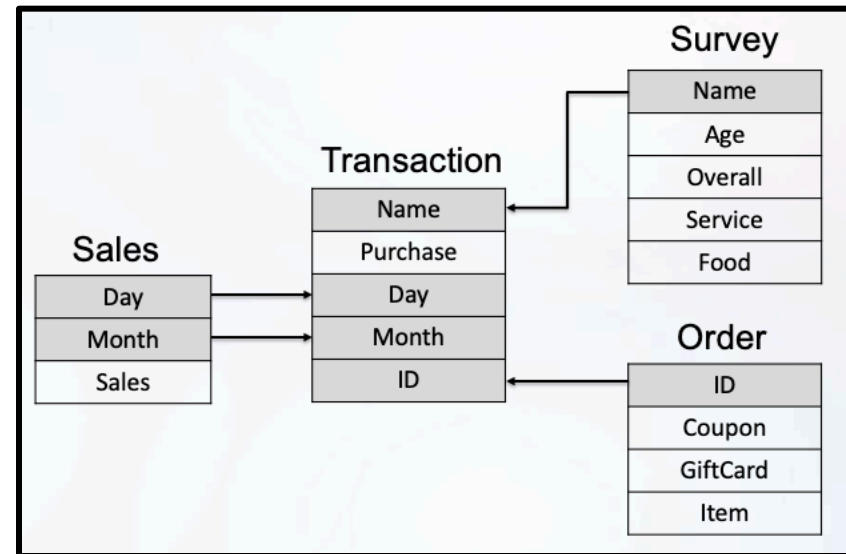
Keys

- 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"
```

```
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
```

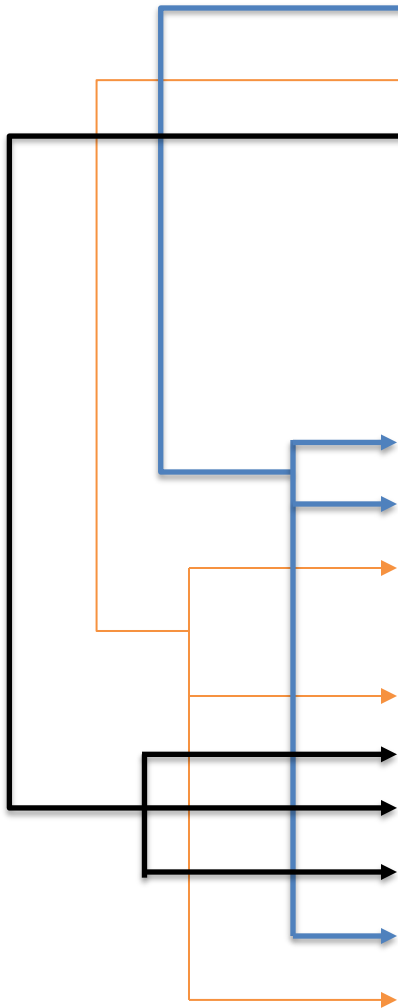
Mutating Joins: Inner Join

Survey

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

Transaction

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



Mutating Joins: Inner Join

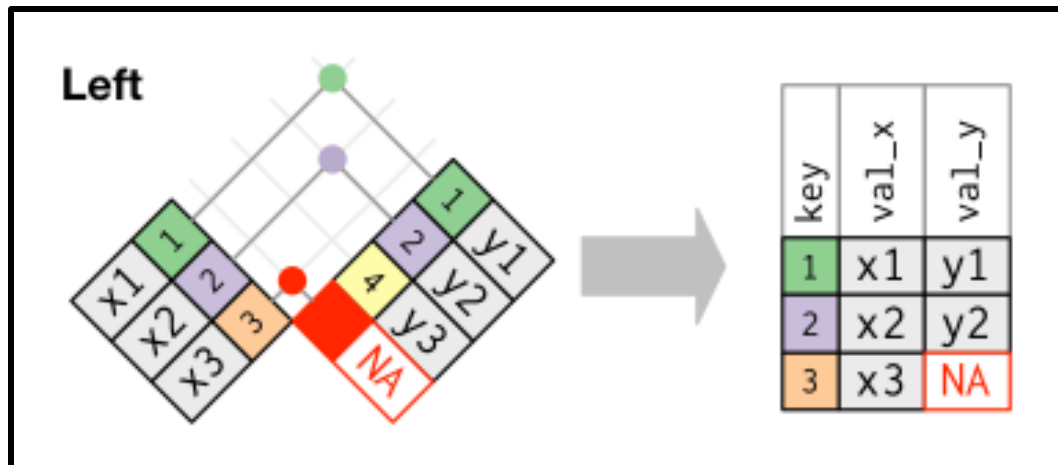
- Inner Joins
 - Example: Survey + Transaction

```
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



Mutating Joins: Left Join

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

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

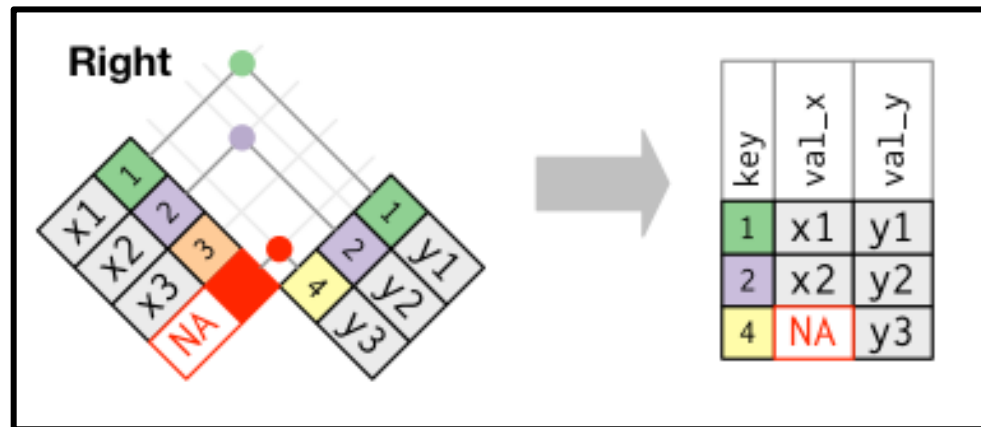
```
SurveyTrans2
```

```
## # 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



Mutating Joins: Right Join

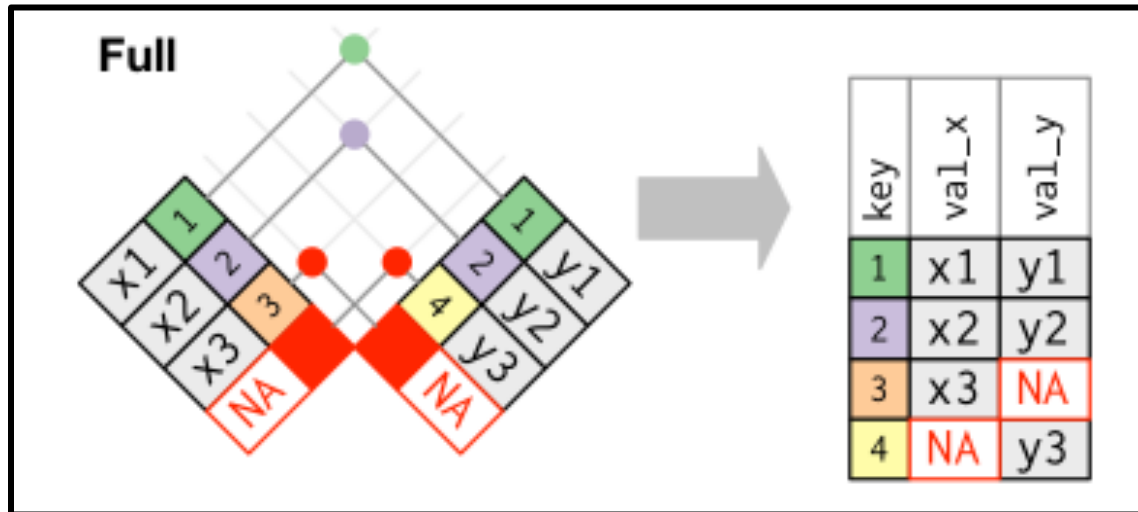
- Outer Joins
 - Right-Join
 - Example: Survey + Trans.

```
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



Mutating Joins: Full Join

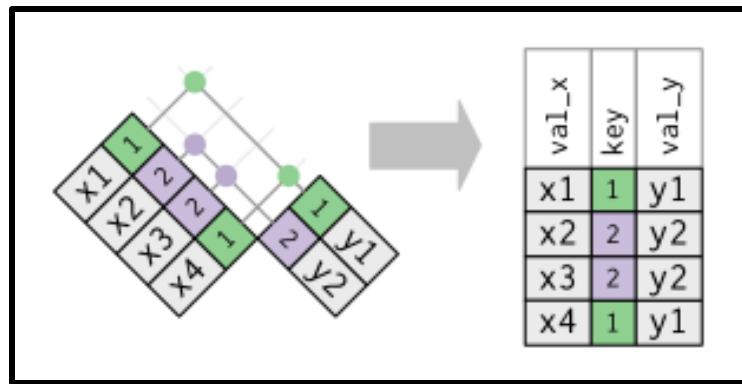
- Outer Joins
 - Full-Join
 - Example: Survey + Trans.

```
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



- 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 `> ifelse(VAR=="OLD", "NEW", VAR)`
 - Repeatedly Use View Function

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