Introduction to the Grammar of Graphics

Prof. Wells

STA 209, 1/30/23

Outline

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- Discuss the Grammar of Graphics
- Decompose particular graphics using the GG paradigm
- Introduce the `ggplot2` package for R graphics

Section 1

The Grammar of Graphics

The Guiding Principle

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Planet Name	color	bar

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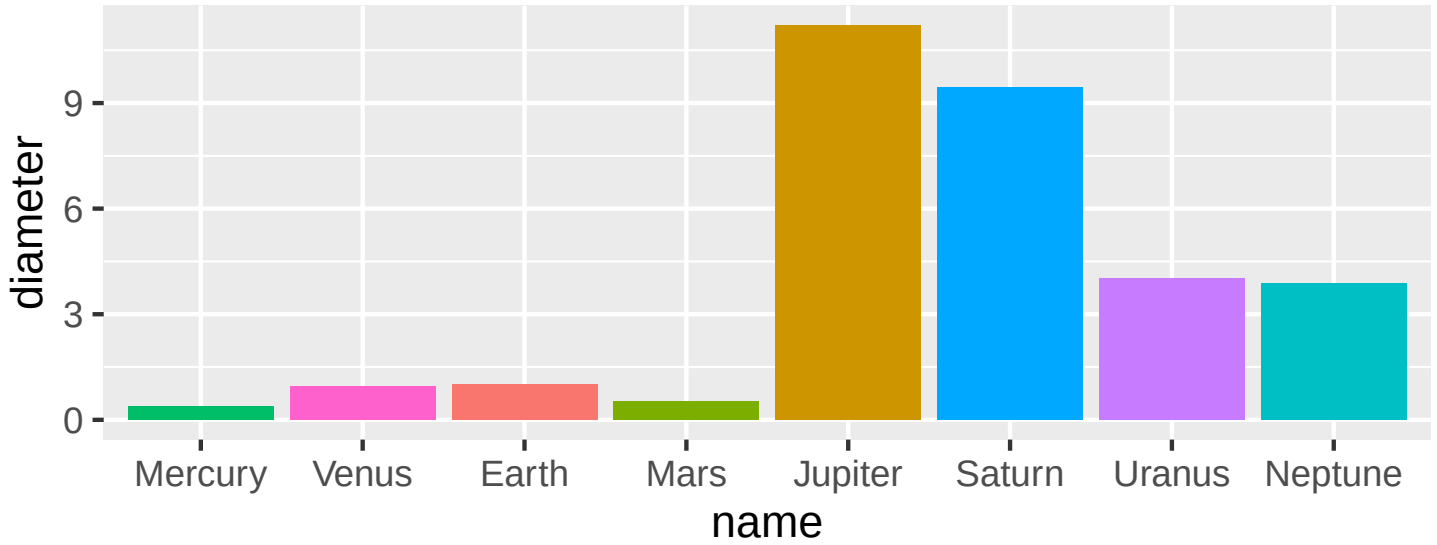
Planet Diameter	y height	bar
Planet Name	color	bar

```
ggplot(data = planets_df) +
  geom_bar(stat = "identity",  mapping = aes(x = name, y = diameter, fill  = name)
```



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  i.e. specifying particular colors or shapes
- **guide**: a legend to help user convert visual display back to the data

Plotting the Planets

Consider the planets data frame, `planets_df`:

name	type	diameter	rotation	rings	distance
Mercury	Terrestrial planet	0.382	58.64	FALSE	0.4
Venus	Terrestrial planet	0.949	-243.02	FALSE	0.7
Earth	Terrestrial planet	1.000	1.00	FALSE	1.0
Mars	Terrestrial planet	0.532	1.03	FALSE	1.5
Jupiter	Gas giant	11.209	0.41	TRUE	5.2
Saturn	Gas giant	9.449	0.43	TRUE	9.5
Uranus	Gas giant	4.007	-0.72	TRUE	19.2
Neptune	Gas giant	3.883	0.67	TRUE	30.1

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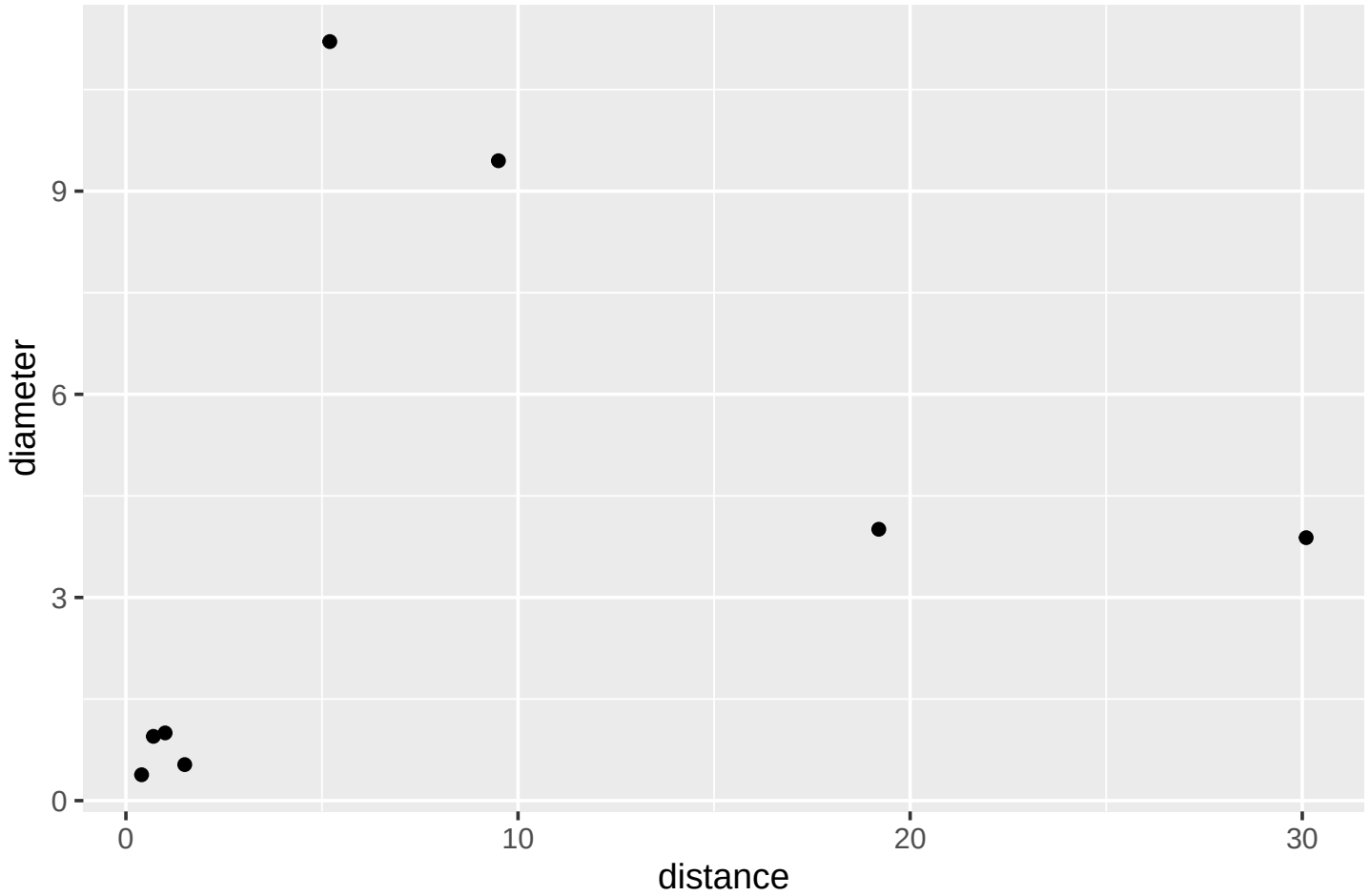
Describe how to create a plot of distance vs. diameter.

Plotting the Planets

```
ggplot(data = planets_df, mapping = aes(x = distance, y = diameter)) +
  geom_point()
```



Decomposing Graphics

Let's get some practice decomposing visualizations using the grammar of graphics. For each of images on the next slides, we'll answer the following:

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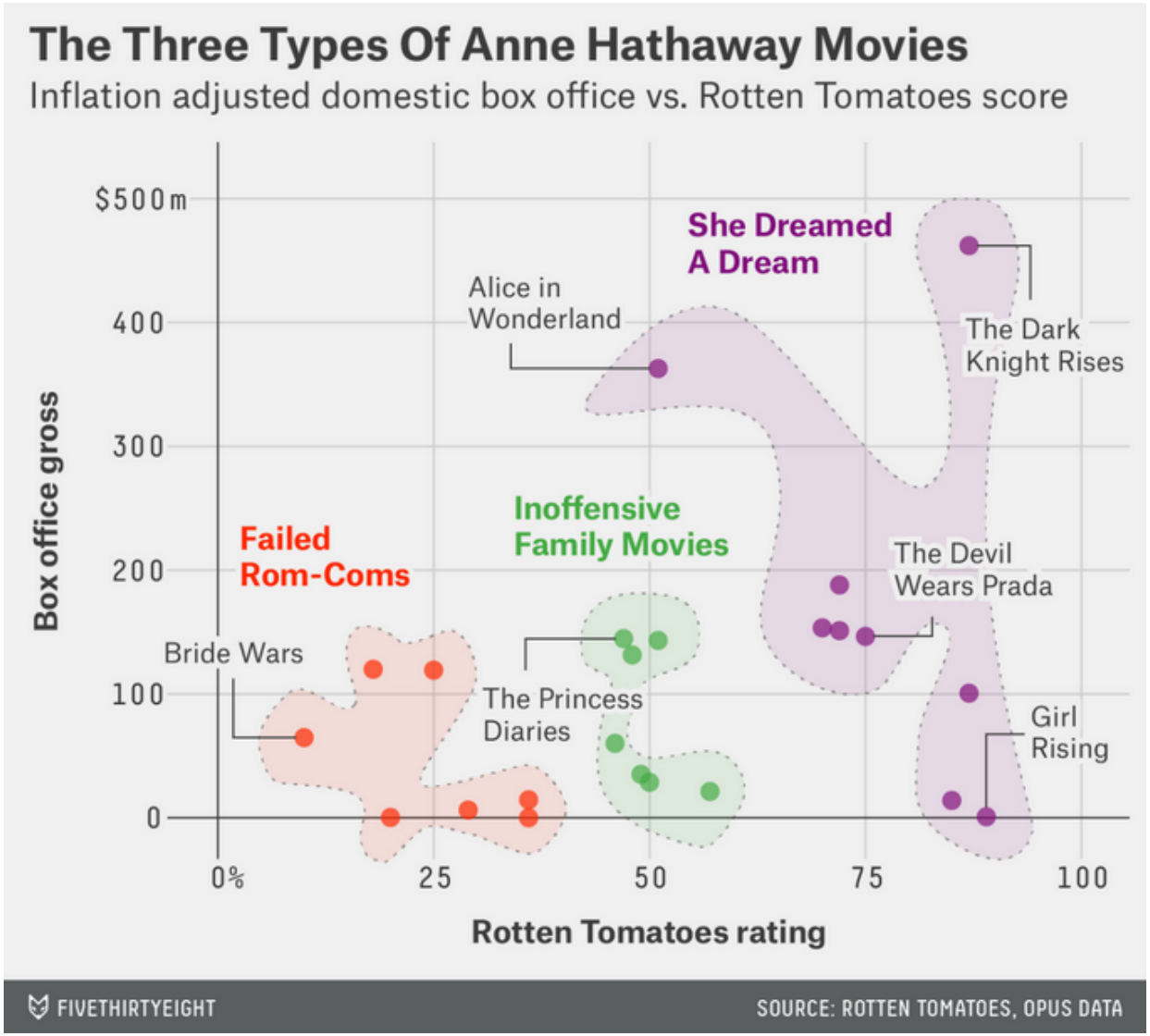
4. What are the **aesthetics** of the **geom**? Which variable sets the value of that **aesthetic**?
5. What additional context does this graphic provide?

Example 1 Graphic



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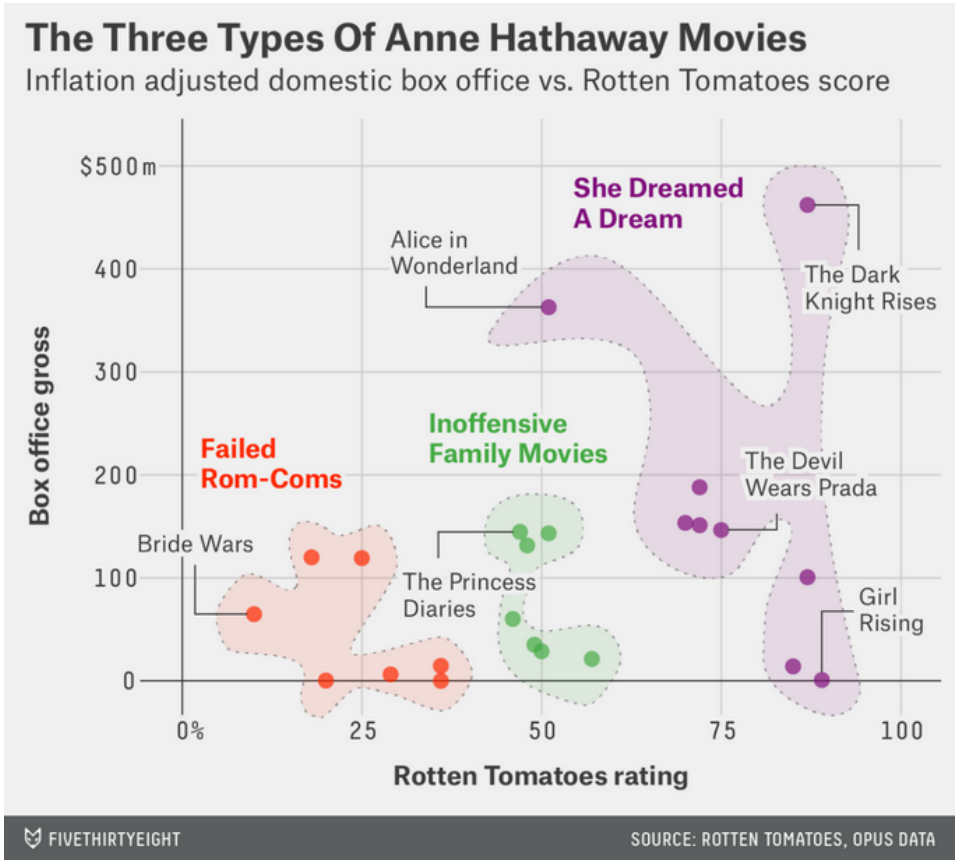
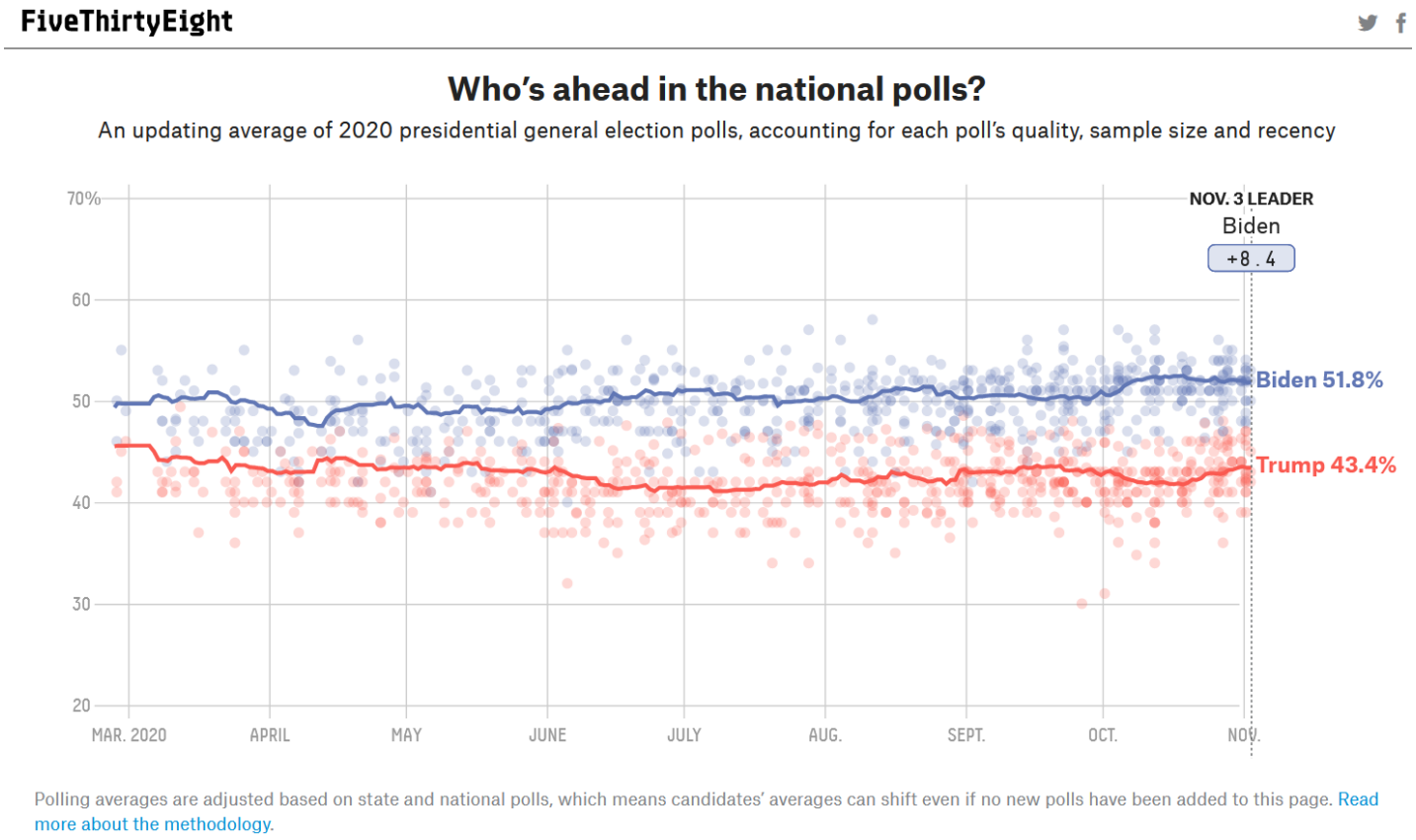


Example 2 Graphic



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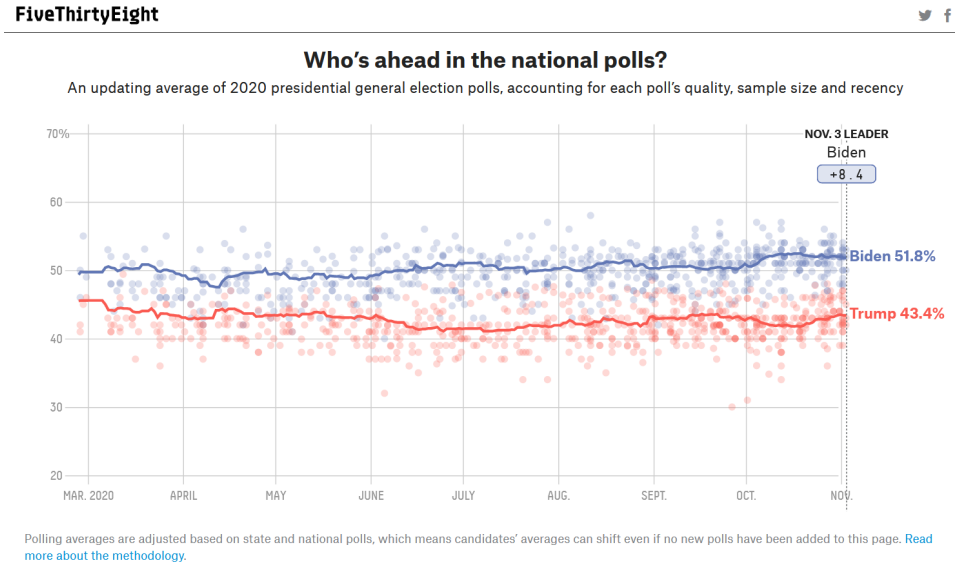

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- Specify your data source for reproducibility/verification.
- Minimize/eliminate extraneous elements that do not serve main purpose.

Section 2

The ggplot2 Package

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ggplot(data = ---, mapping = aes(---)) +
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```
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  geom_---(---)
```

- For brevity, the above code can also be written as:

```
ggplot(---, aes(---)) +
  geom_---(---)
```

- R will assume that the first argument is the data argument and the second argument is the mapping argument.

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- What advantages does ggplot2 (and the Grammar of Graphics) have over these other tools?

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- Several other applications have capability of plotting graphics.
  - Excel and Google Spreadsheets each have separate buttons to produced bar plots, scatter plots, line plots, etc. from data sets.
- What advantages does ggplot2 (and the Grammar of Graphics) have over these other tools?
  - Control
  - Intentionality
  - Consistency
  - Ability to create publication quality graphs with minimal tuning

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  2. Linegraphs (`geom_line`)
  3. Histograms (`geom_histogram`)
  4. Boxplots (`geom_boxplot`)
  5. Barplots (`geom_bar`)
- Other common graph types you may encounter:
  - Violin plots (`geom_violin`)
  - Interpolation (`geom_smooth`)
  - Geographic maps (`geom_map`)
  - Polygon areas (`geom_poly`)
  - Density plots (`geom_density`)

Portland Biketown

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- Users can purchase a single-ride fare, a day pass, or an annual membership. They can borrow a bike from any bike station, and return the bike to any station.
- Bike stations automatically log data on each trip.
- The `biketown` data was obtained from the `BiketownPDX` website and contains a random sample of all bike share rides between July and September, 2017.

Biketown Preview

- First, let's preview the data frame:

```
glimpse(biketown)
```

```
## Rows: 9,999
## Columns: 19
## $ RouteID          <dbl> 4074085, 3719219, 3789757, 3576798, 3459987, 3947695,~
## $ PaymentPlan      <chr> "Subscriber", "Casual", "Casual", "Subscriber", "Casu~
## $ StartHub         <chr> "SE Elliott at Division", "SW Yamhill at Director Par~
## $ StartLatitude    <dbl> 45.50513, 45.51898, 45.52990, 45.52389, 45.53028, 45.~
## $ StartLongitude   <dbl> -122.6534, -122.6813, -122.6628, -122.6722, -122.6547~
## $ StartDate        <chr> "8/17/2017", "7/22/2017", "7/27/2017", "7/12/2017", "~
## $ StartTime        <time> 10:44:00, 14:49:00, 14:13:00, 13:23:00, 19:30:00, 10~
## $ EndHub           <chr> "Blues Fest - SW Waterfront at Clay - Disabled", "SW ~
## $ EndLatitude      <dbl> 45.51287, 45.52142, 45.55902, 45.53409, 45.52990, 45.~
## $ EndLongitude     <dbl> -122.6749, -122.6726, -122.6355, -122.6949, -122.6628~
## $ EndDate          <chr> "8/17/2017", "7/22/2017", "7/27/2017", "7/12/2017", "~
## $ EndTime          <time> 10:56:00, 15:00:00, 14:42:00, 13:38:00, 20:30:00, 10~
## $ TripType         <lgl> NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, N~
## $ BikeID           <dbl> 6163, 6843, 6409, 7375, 6354, 6088, 6089, 5988, 6857,~
## $ BikeName         <chr> "0488 BIKETOWN", "0759 BIKETOWN", "0614 BIKETOWN", "0~
## $ Distance_Miles   <dbl> 1.91, 0.72, 3.42, 1.81, 4.51, 5.54, 1.59, 1.03, 0.70,~
## $ Duration         <dbl> 11.500, 11.383, 28.317, 14.917, 60.517, 53.783, 23.86~
## $ RentalAccessPath <chr> "keypad", "keypad", "keypad", "keypad", "keypad", "ke~
## $ MultipleRental   <lgl> FALSE, FALSE, FALSE, FALSE, TRUE, FALSE, FALSE, FALSE~
```

A Deeper Dive I

What do the first few entries look like?

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```
head(biketown)
```

```
## # A tibble: 6 x 19
##   RouteID Payme~1 Start~2 Start~3 Start~4 Start~5 Start~6 EndHub EndLa~7 EndLo~8
##     <dbl> <chr>   <chr>     <dbl>   <dbl> <chr>   <time>  <chr>    <dbl>   <dbl>
## 1 4074085 Subscr~ SE Ell~    45.5   -123. 8/17/2~ 10:44   Blues~    45.5   -123.
## 2 3719219 Casual  SW Yam~    45.5   -123. 7/22/2~ 14:49   SW 2n~    45.5   -123.
## 3 3789757 Casual  NE Hol~    45.5   -123. 7/27/2~ 14:13   NE Al~    45.6   -123.
## 4 3576798 Subscr~ NW Cou~    45.5   -123. 7/12/2~ 13:23   NW Ra~    45.5   -123.
## 5 3459987 Casual  NE 11t~    45.5   -123. 7/3/20~ 19:30   NE Ho~    45.5   -123.
## 6 3947695 Casual  SW Moo~    45.5   -123. 8/8/20~ 10:01   SW 3r~    45.5   -123.
## # ... with 9 more variables: EndDate <chr>, EndTime <time>, TripType <lgl>,
## #   BikeID <dbl>, BikeName <chr>, Distance_Miles <dbl>, Duration <dbl>,
## #   RentalAccessPath <chr>, MultipleRental <lgl>, and abbreviated variable
## #   names 1: PaymentPlan, 2: StartHub, 3: StartLatitude, 4: StartLongitude,
## #   5: StartDate, 6: StartTime, 7: EndLatitude, 8: EndLongitude
## # i Use `colnames()` to see all variable names
```

A Deeper Dive II

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```
biketown$Distance_Miles
```

```
##    [1]  1.91  0.72  3.42  1.81  4.51  5.54  1.59  1.03  0.70  1.72  1.79  3.15
##   [13]  0.81  0.55  5.78  0.41  3.76  2.22  1.77  4.96  3.19  2.56  2.55  0.68
##   [25]  0.59  0.71  3.15  5.89  1.34  1.56  3.50  1.81  2.74  4.56  3.99  1.03
##   [37]  1.51  2.87  2.60  1.48  0.96  2.82  0.66  0.37  2.38  5.92  1.27  0.78
##   [49]  0.79  3.38  1.73  3.64  1.40  2.61  1.85  1.04  1.55  0.63  3.41  4.94
##   [61]  3.93  0.40  1.00  7.19  7.15  0.96  0.33  0.79  2.80  1.08  2.27  0.62
##   [73]  0.50  2.15  0.23  3.06  1.85  5.00  0.42  3.05  0.42  1.00  4.09  0.45
##   [85]  2.53  0.66  0.26  1.89  1.63  0.99  1.62  1.87  6.73 12.95  3.44  0.43
##   [97]  0.82  0.72  1.51  1.70  0.34  0.55  2.84  1.31  2.78  1.09  1.25  5.04
##  [109]  1.18  1.15  1.62  0.63  3.88  4.67  1.25  0.34  3.11  5.29  1.00  1.67
##  [121]  0.61  0.47  0.68  0.66  0.71  0.02  0.87  1.61  4.50  1.47  4.53  0.10
##  [133]  0.25  5.50  2.05  4.98  0.66  0.12  4.79  0.47  4.19  0.43  1.57  0.27
##  [145]  0.17  1.08  0.36  5.16  6.74  2.54  0.48  0.91  1.80  0.19  2.71  1.32
##  [157]  2.75  1.14  0.65  2.58  3.77  0.66  3.55  1.37  0.98  1.41  1.01  1.87
##  [169]  0.51  0.37  1.12  0.84  0.55  0.12  3.64  4.69  0.15  2.94  5.06  1.24
##  [181]  0.83  2.32  1.25  2.82  0.61  1.80  1.41  1.16  1.09  2.03  1.34  0.55
##  [193]  0.45  4.79  4.30  0.45  2.05  0.71  0.16  0.31  0.01  1.49  3.27  3.11
##  [205]  0.78  2.62  0.63  2.09  1.83  0.35  0.82  1.39  2.39  0.58  0.36  0.28
##  [217]  1.65  0.79  1.90  1.27  3.71  2.96  7.12  3.20  0.40  1.50  0.93  1.97
##  [229]  0.73  0.68  0.91  3.20  2.27  2.67  2.37  0.05  0.82  2.50  2.17  0.44
##  [241]  2.79  0.07  0.66  1.93  1.78  0.59  1.54  1.59  1.47  0.62  1.63  2.68
##  [253]  0.27  1.46  0.68  0.16  0.42  0.55  1.47  0.27  2.02  0.85  0.63  0.58
##  [265]  0.60  0.56  2.12  1.48  0.60  0.88  0.62  0.48  2.55  0.82  0.97  3.45
```

A Deeper Dive II

- To determine the variable type in R, use `class`

```
class(biketown$Distance_Miles)
```

```
## [1] "numeric"
```

```
class(biketown$PaymentPlan)
```

```
## [1] "character"
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```
names(biketown)
```

```
##  [1] "RouteID"          "PaymentPlan"      "StartHub"         "StartLatitude"
##  [5] "StartLongitude"   "StartDate"        "StartTime"        "EndHub"
##  [9] "EndLatitude"      "EndLongitude"     "EndDate"          "EndTime"
## [13] "TripType"         "BikeID"           "BikeName"         "Distance_Miles"
## [17] "Duration"         "RentalAccessPath" "MultipleRental"
```

Section 3

Types of Graphics

Scatterplots

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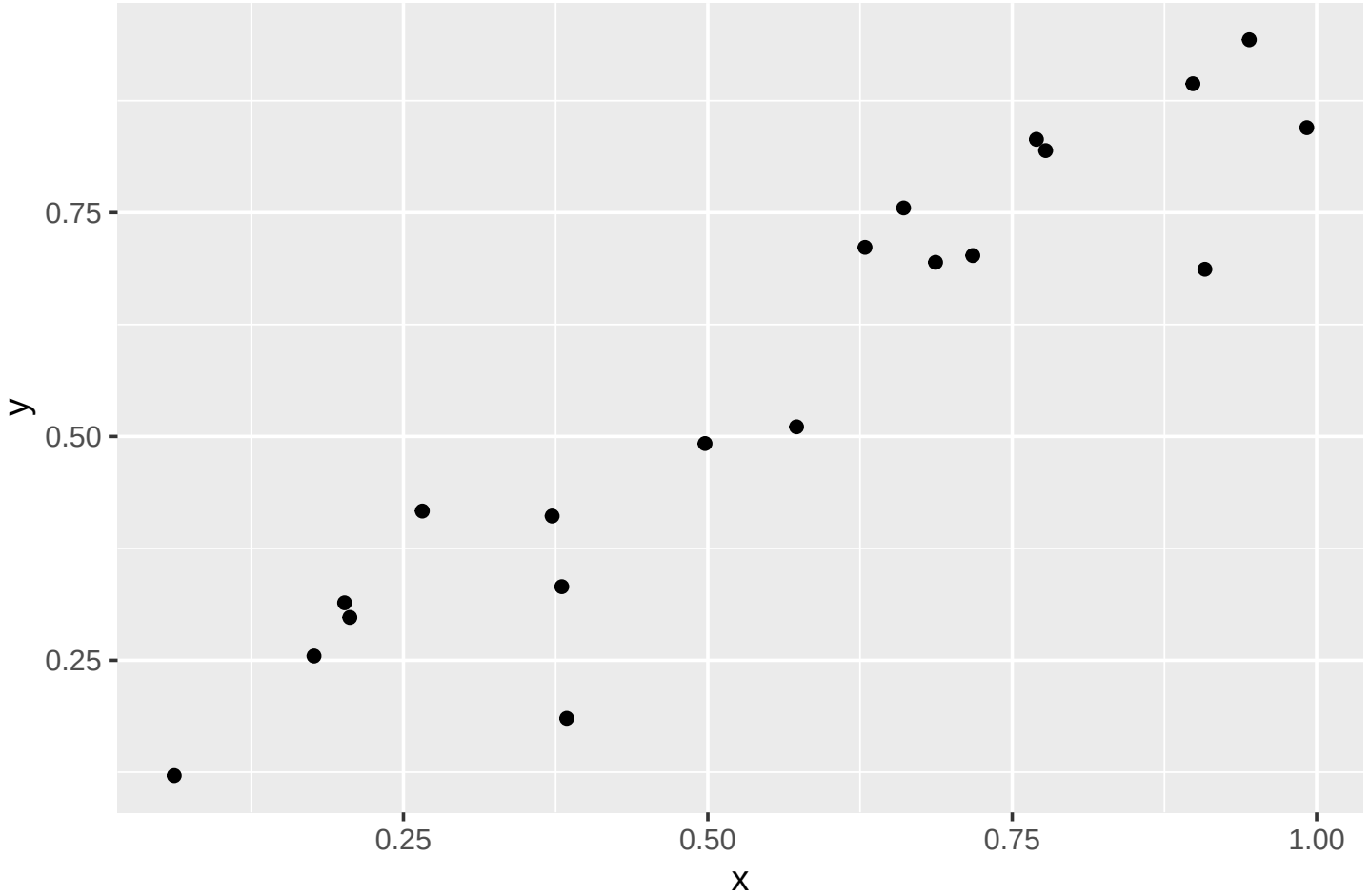

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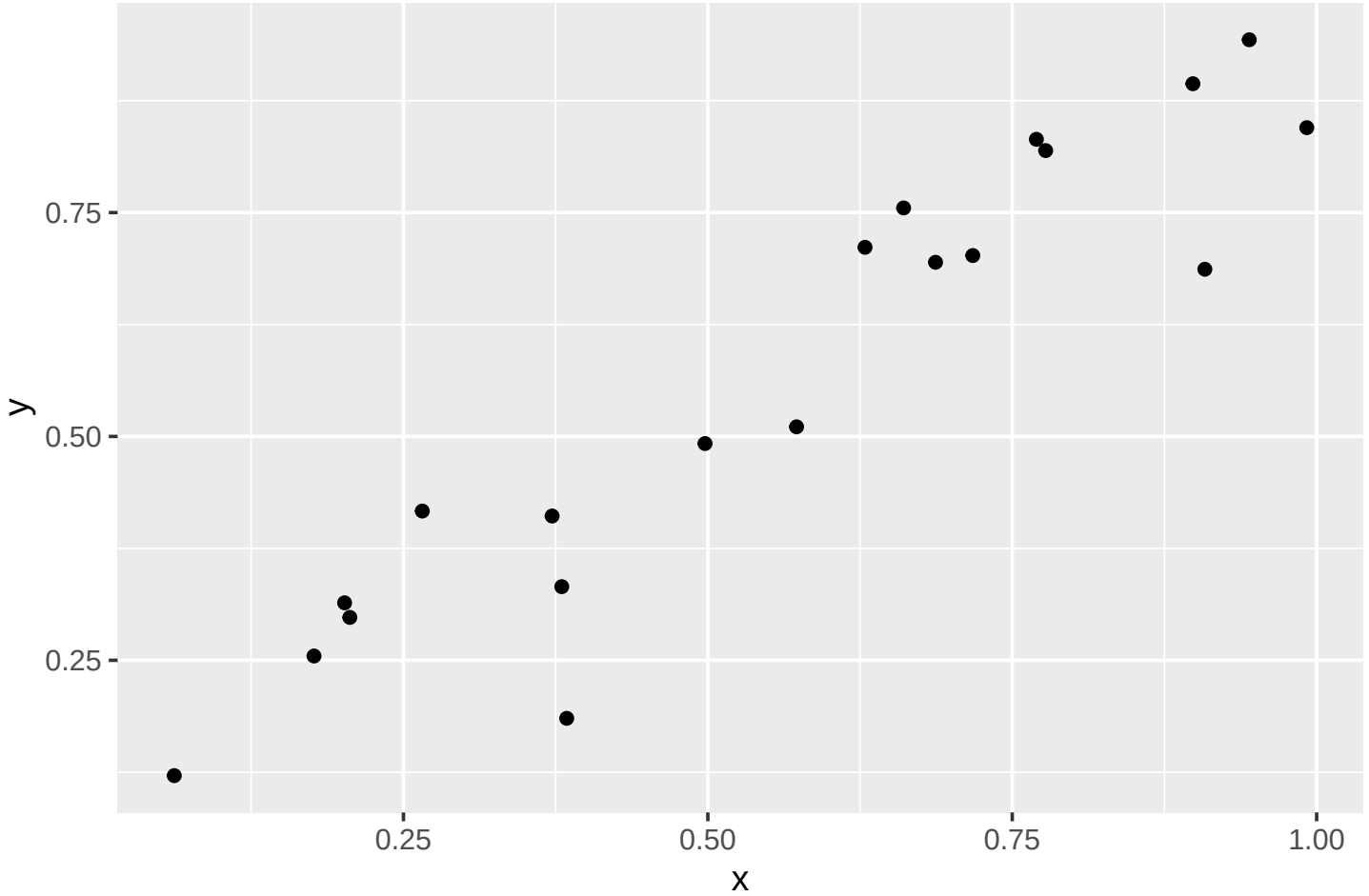

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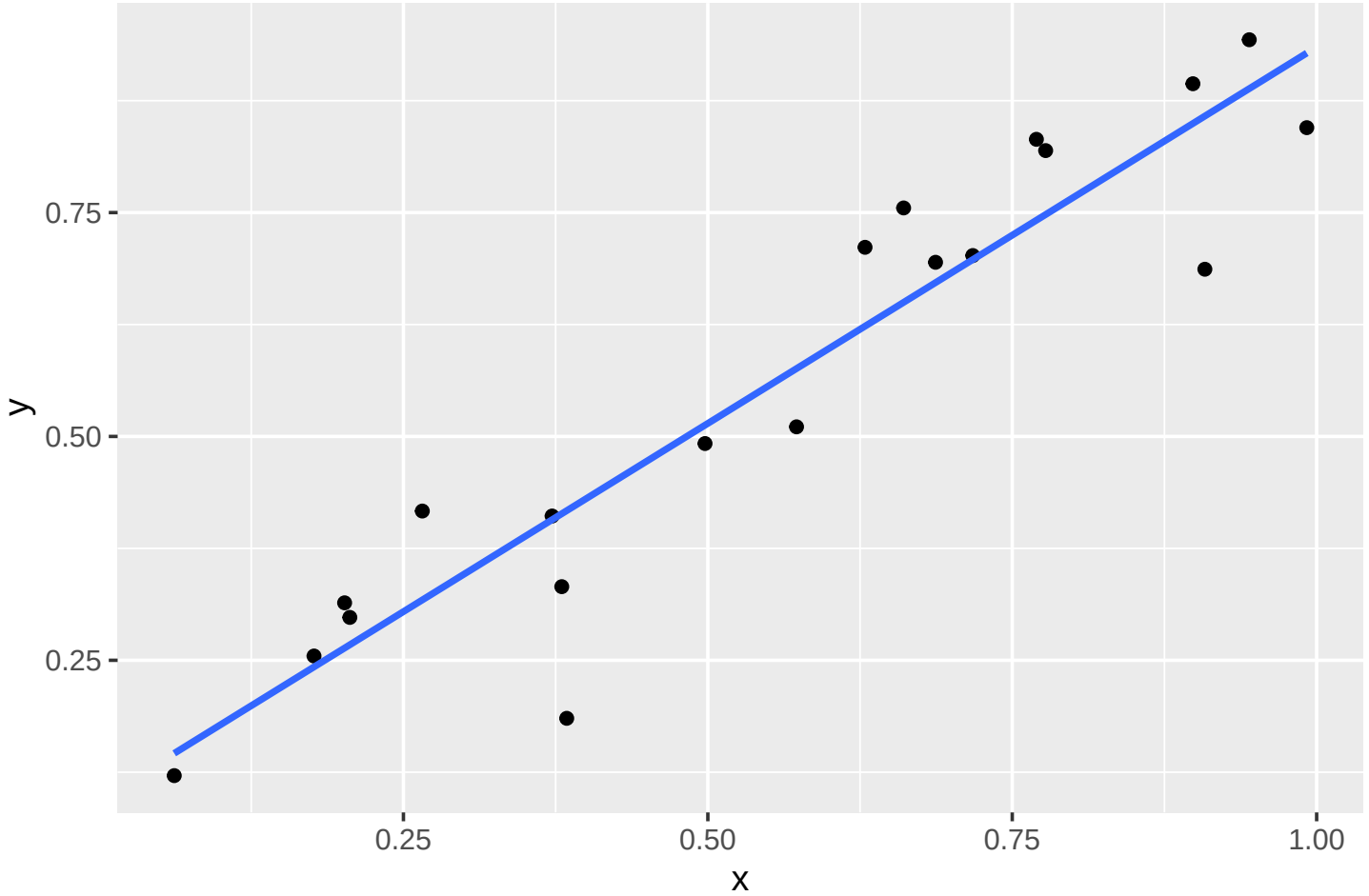

- In particular, we are often interested in **linear** relationships.

Linear Relationships

- Two variables have a **positive** relationship provided the values of one increase as the values of the other also increase.

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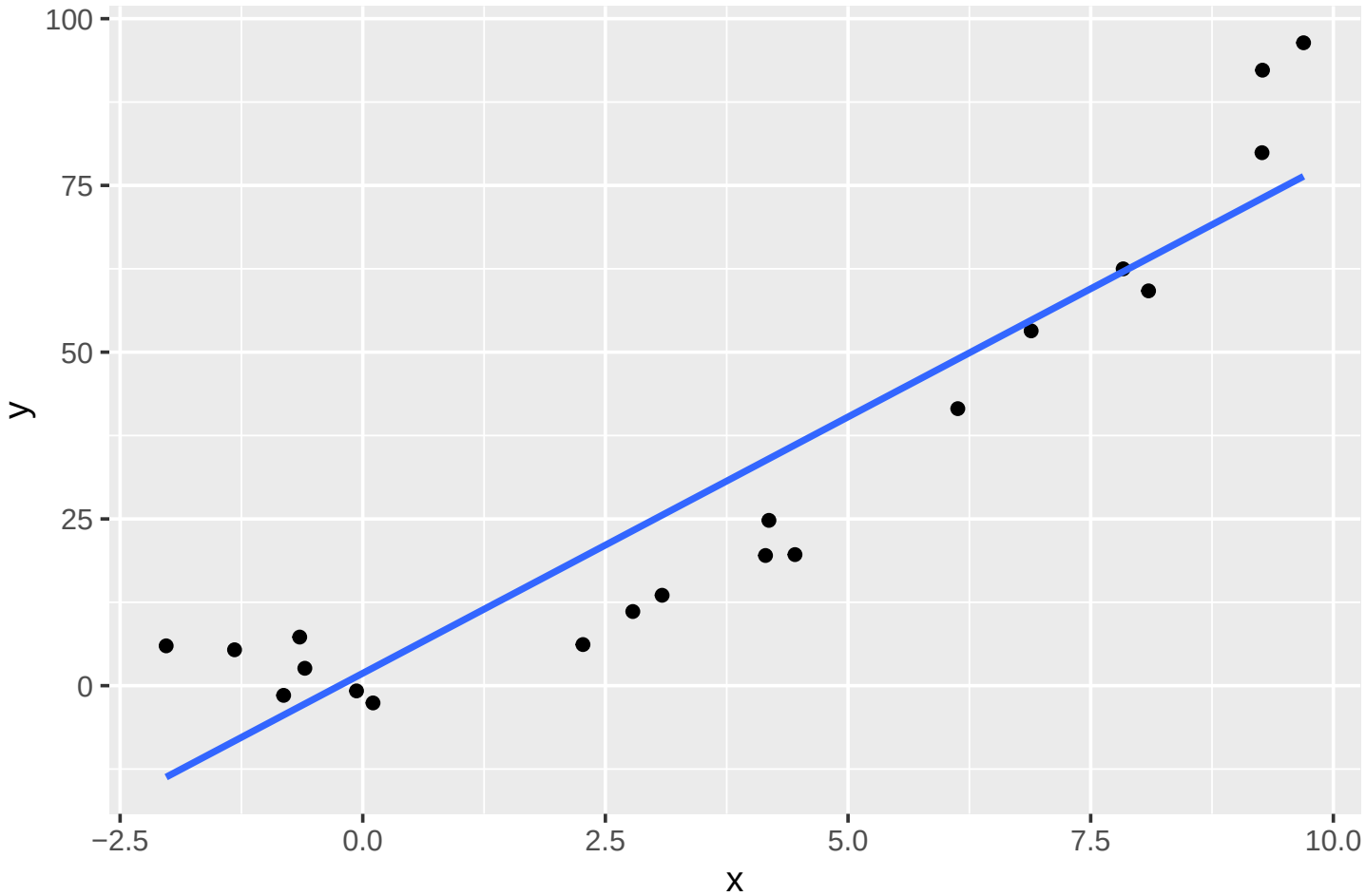
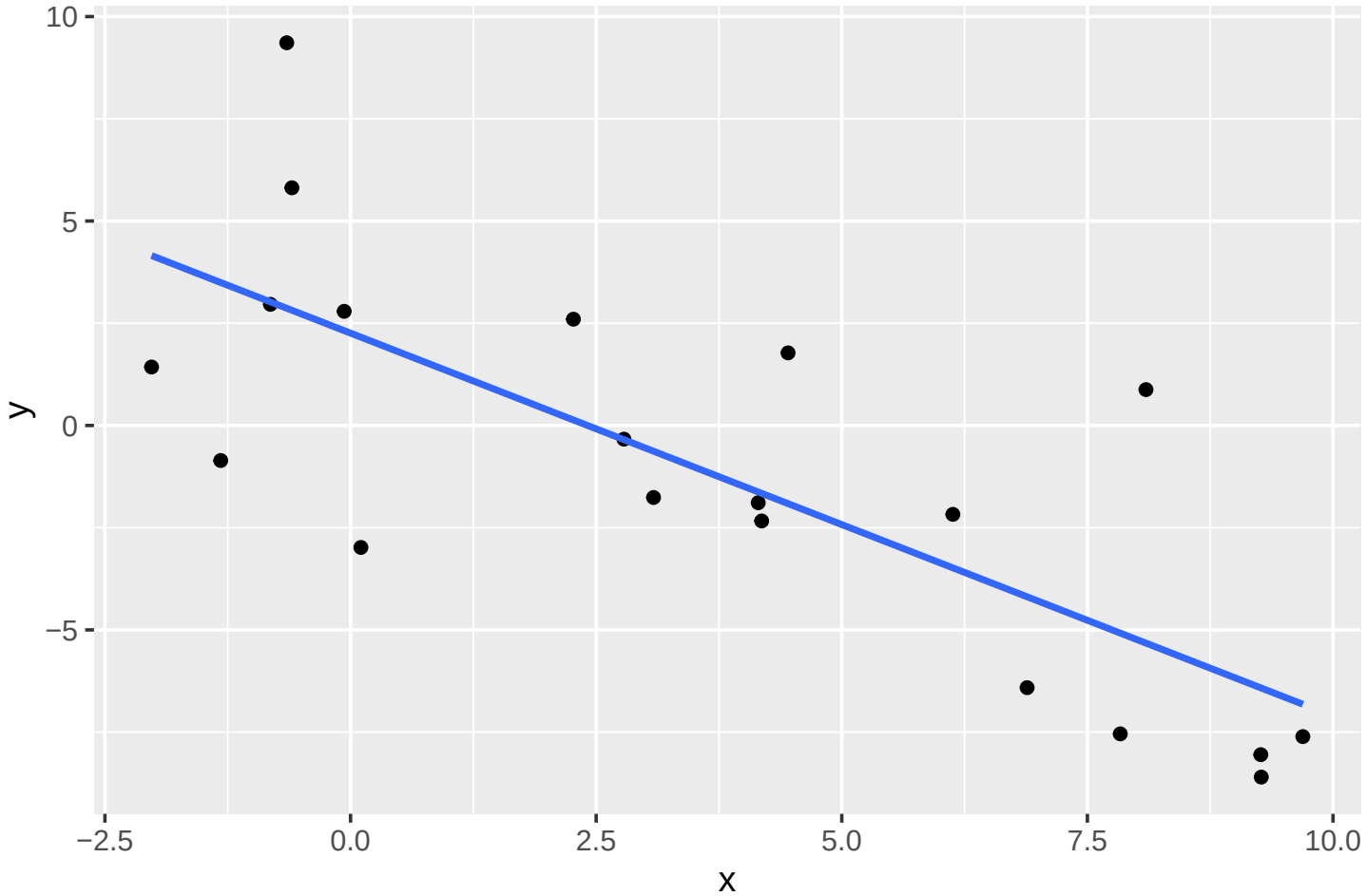


Linear Relationships

- Two variables have a **negative** relationship provided the values of one decrease as the values of the other also increase.

Linear Relationships

- Two variables have a **negative** relationship provided the values of one decrease as the values of the other also increase.



Linear Relationships

- What type of relationshop do we expect if the values of one variable **decrease** as the values of the other also **decrease**?

Linear Relationships

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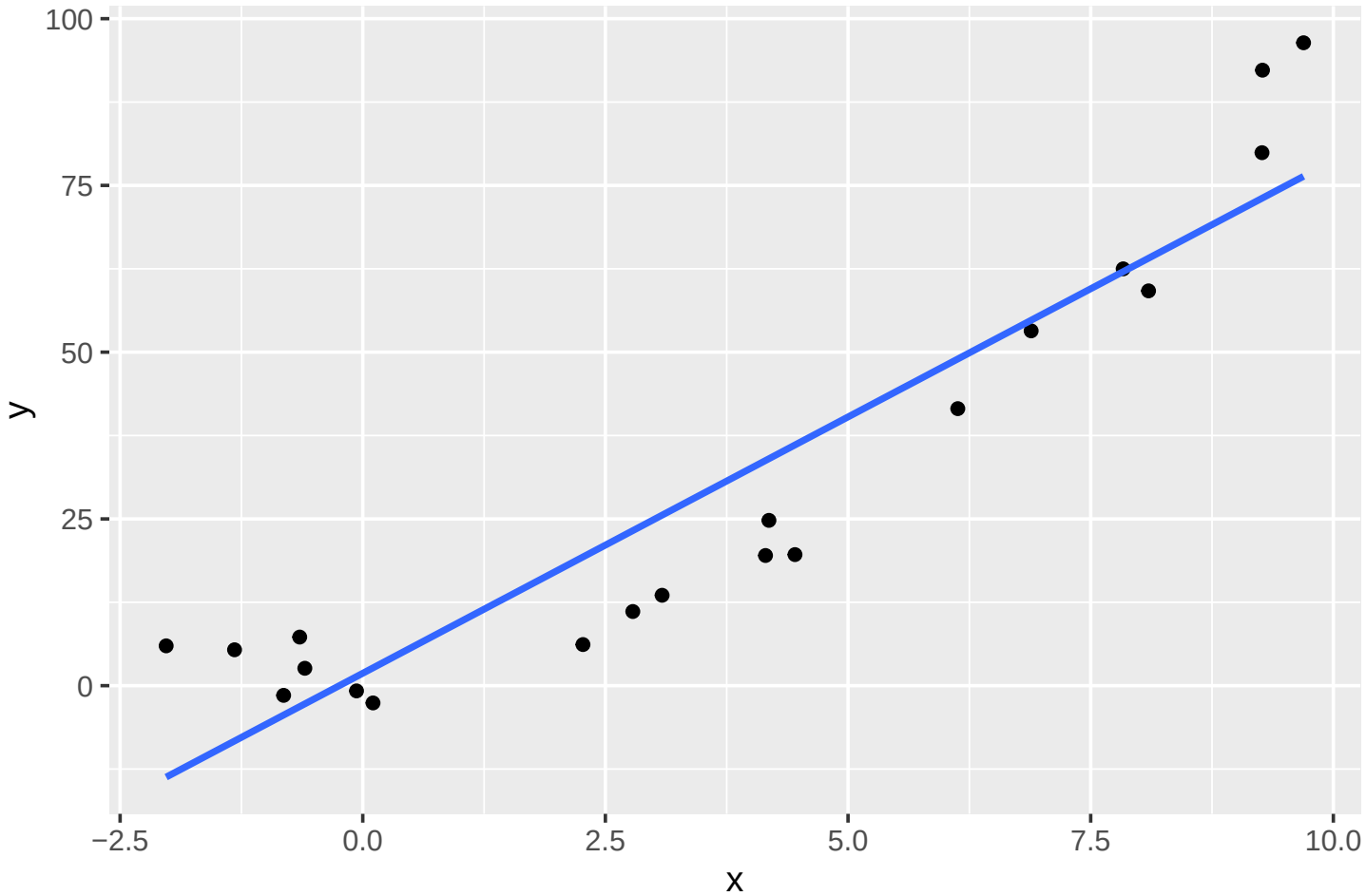

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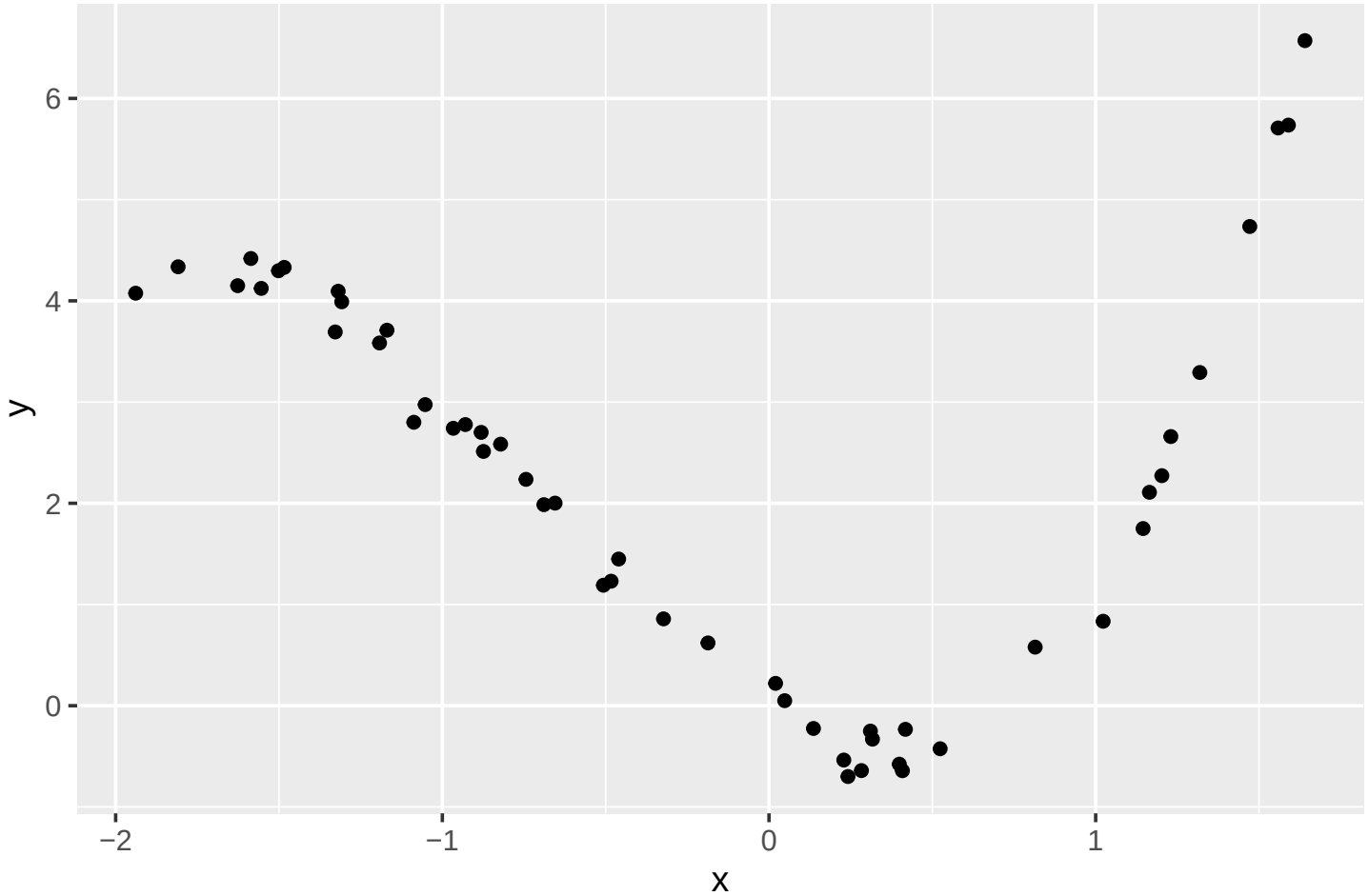

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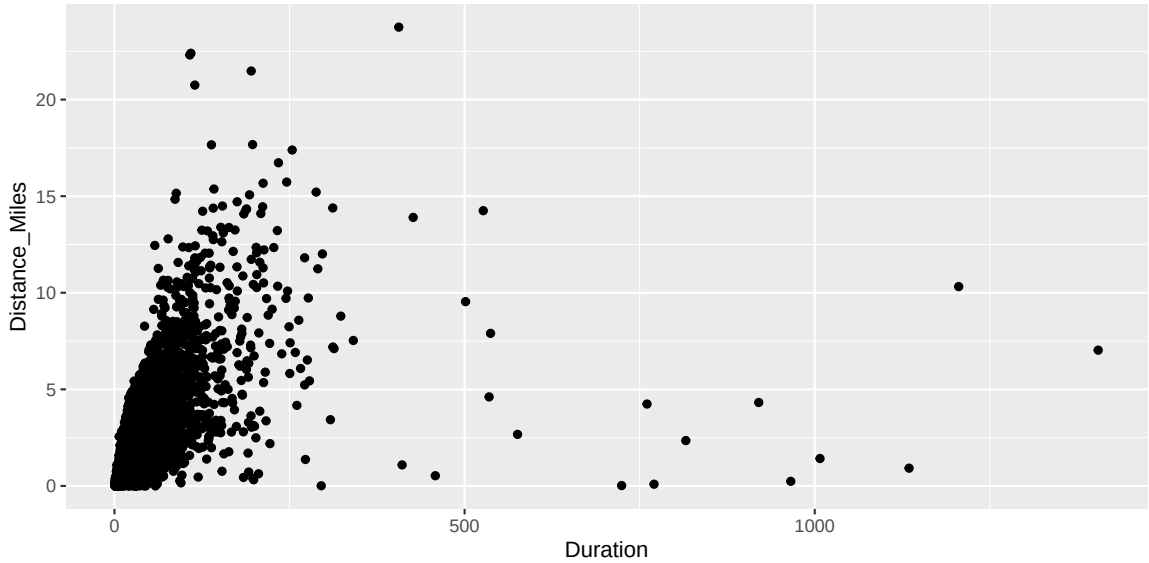

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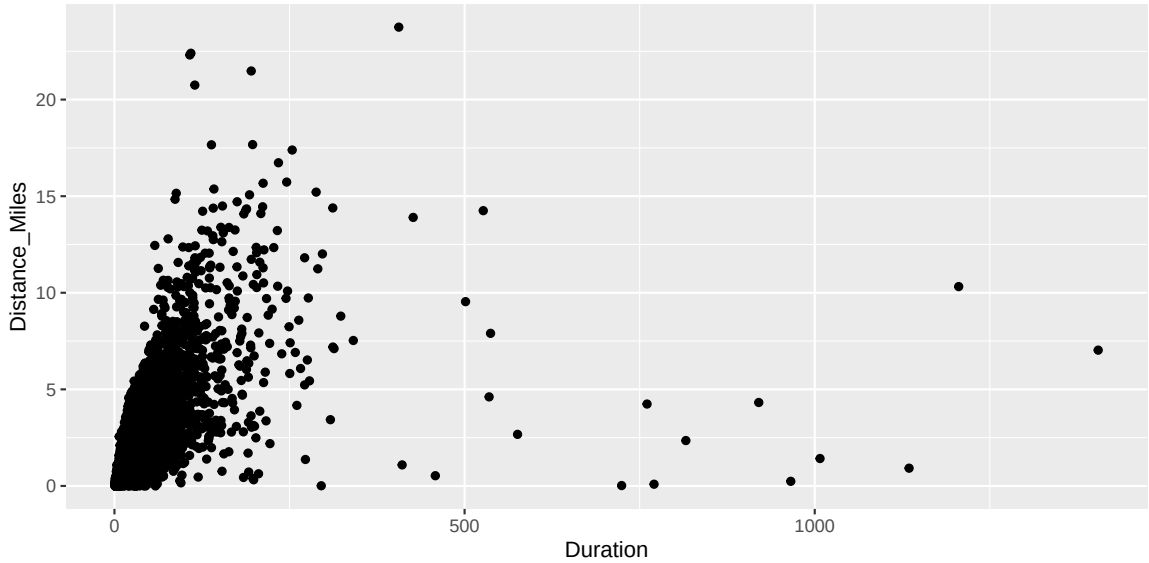

- Problems with the graphic?

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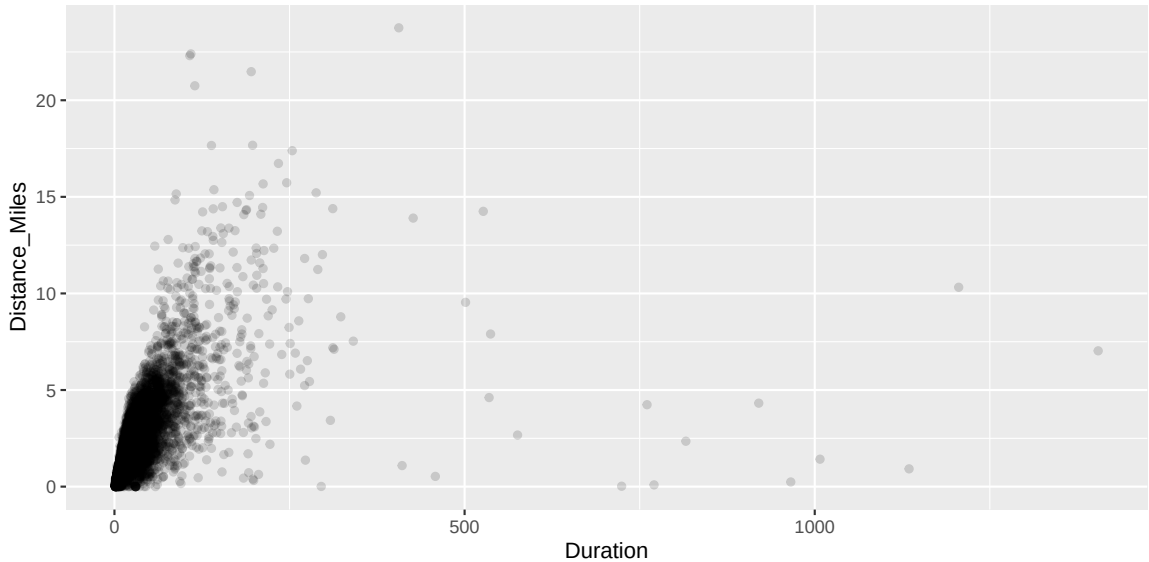

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ggplot(data = biketown, mapping = aes(x = Duration, y = Distance_Miles)) +
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  scale_y_continuous(limits = c(0, 10))
```

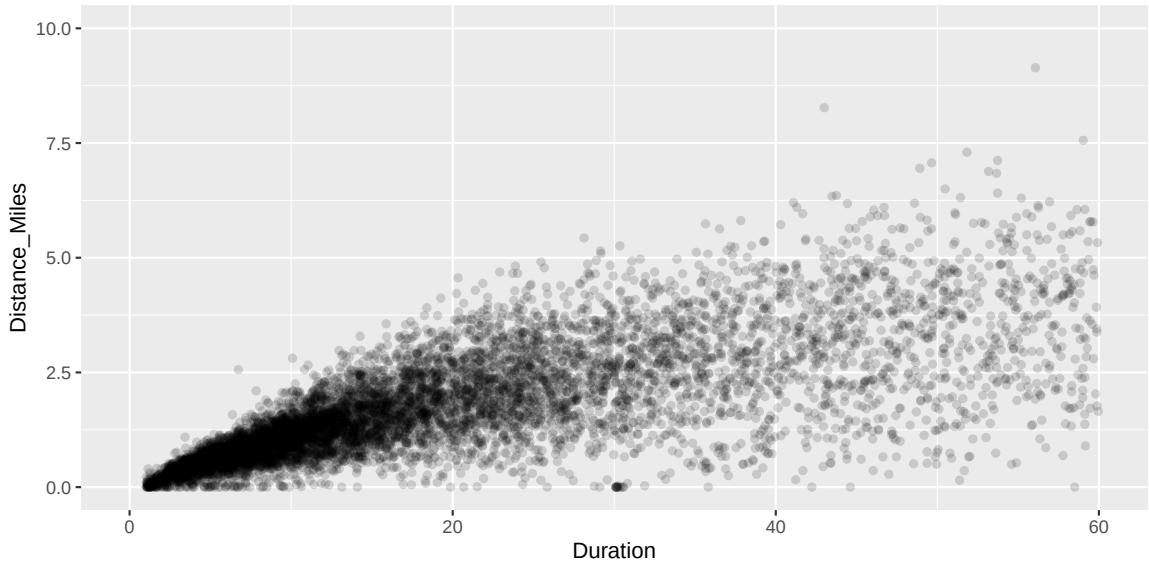

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ggplot(data = jiggle_df, mapping = aes(x = x, y = y)) +
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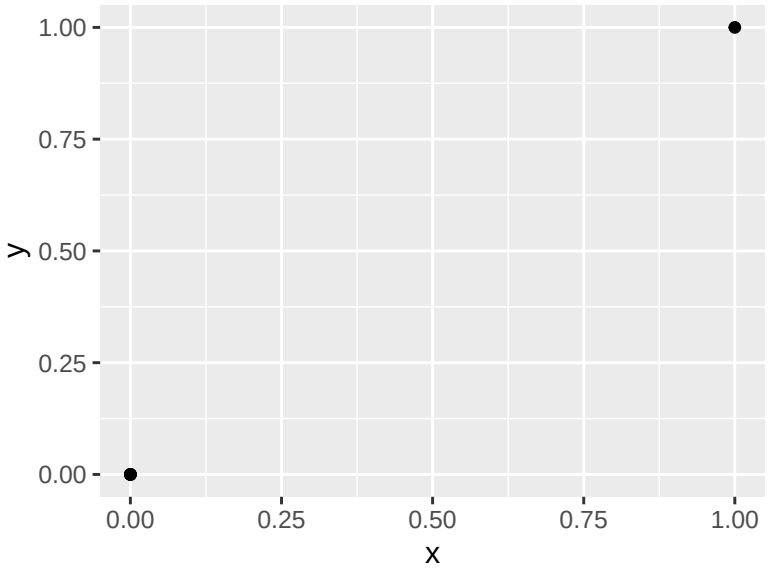

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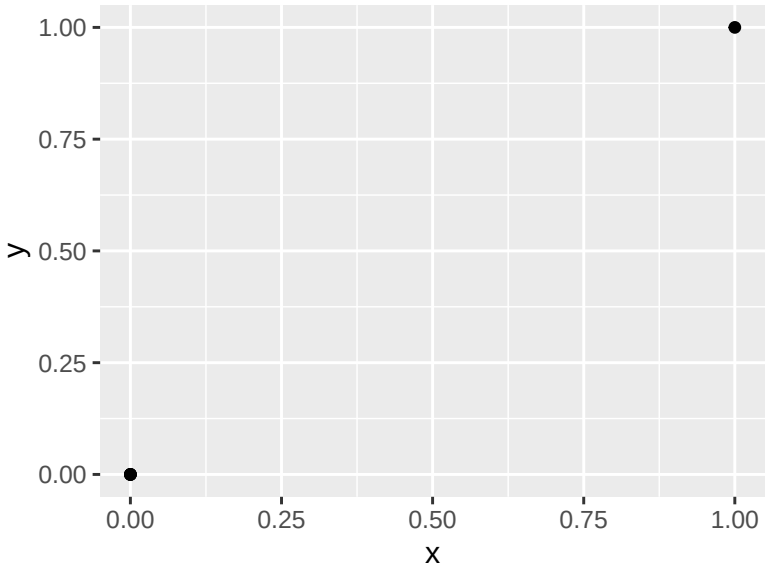

- It looks like there are just 2 observations!

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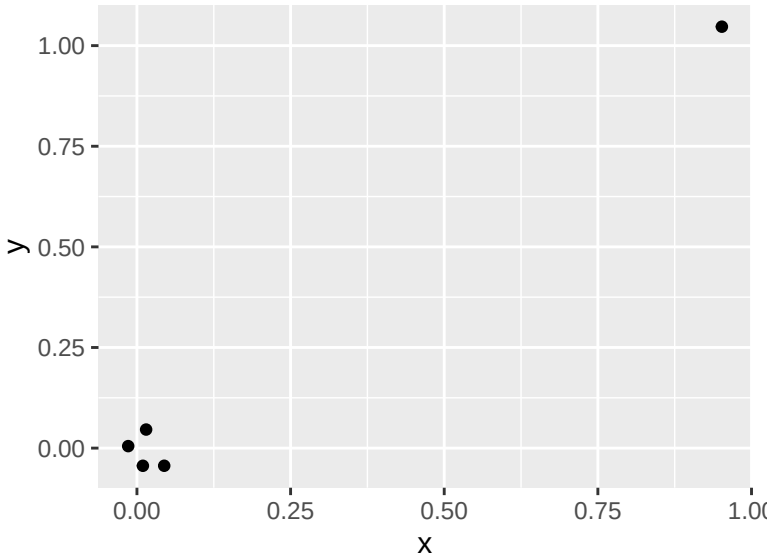

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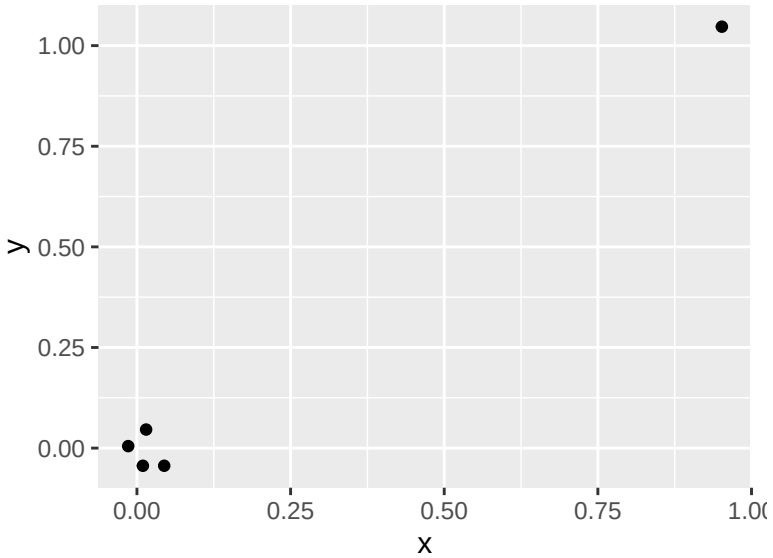

- To jitter points, use the layer `geom_jitter(width = ..., height = ...)` instead of `geom_points()`