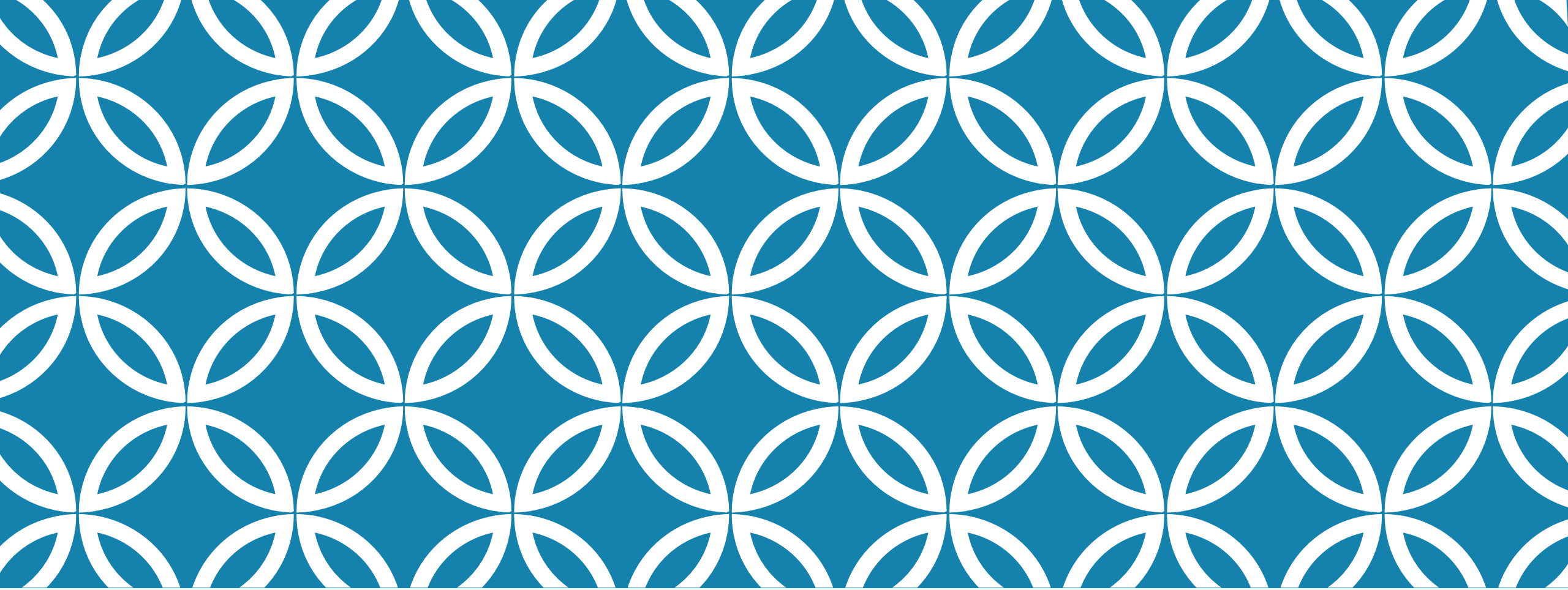

Data Visualization

Session 3

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December 13, 2020

Visualization Lecture Courtesy of Stephan Kadauke

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University of Pennsylvania Perelman School of Medicine

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Children's Hospital of Philadelphia

Goals

1. Appreciate the importance of visualization for understanding data
2. Learn how to use ggplot2 to visualize data

Objectives

1. Create a basic visualization using a simple template
2. Define “aesthetic mapping” and explain how aesthetic mappings relate variables of a data frame to features of graphic markings on a plot
3. Write the code to specify a type of plot and fine tune its appearance using “geom” functions
4. Explain how to add layers to a ggplot object to create complex and highly customized visualizations

covid_testing

covid_testing

Filter

	mrn	first_name	last_name	gender	pan_day	test_id	clinic_name	result
1	5001412	jhezane	westerling	female	4	covid	inpatient ward a	negative
2	5000533	penny	targaryen	female	7	covid	clinical lab	negative
3	5009134	grunt	rivers	male	7	covid	clinical lab	negative
4	5008518	melisandre	swyft	female	8	covid	clinical lab	negative
5	5008967	rolley	karstark	male	8	covid	emergency dept	negative
6	5011048	megga	karstark	female	8	covid	oncology day hosp	negative
7	5000663	ithoke	targaryen	male	9	covid	clinical lab	negative
8	5002158	ravella	frey	female	9	covid	emergency dept	negative
9	5003794	styr	tyrell	male	9	covid	clinical lab	negative
10	5004706	wynafryd	seaworth	male	9	covid	clinical lab	negative
11	5008115	patrek	frey	male	9	covid	clinical lab	negative
12	5009309	maege	sand	female	9	covid	medical center	negative
13	5008943	myria	rivers	female	9	covid	picu	negative

Showing 1 to 14 of 15,524 entries, 17 total columns

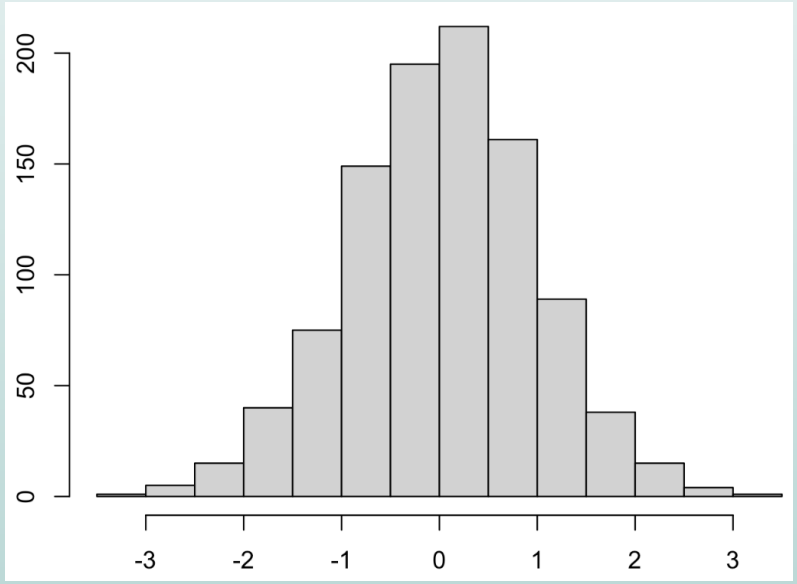
Your Turn 1

Consider the `covid_testing` data frame.

What do you think the plot would look like in which:

- the x-axis represents `pan_day` (day of the pandemic), and
- the y-axis represents the number of tests that were performed on that day?

Your Turn 2



What is the name of this kind of plot?

Type the answer into the chat!

Your Turn 3

Type the following code in the RStudio console to make a graph.

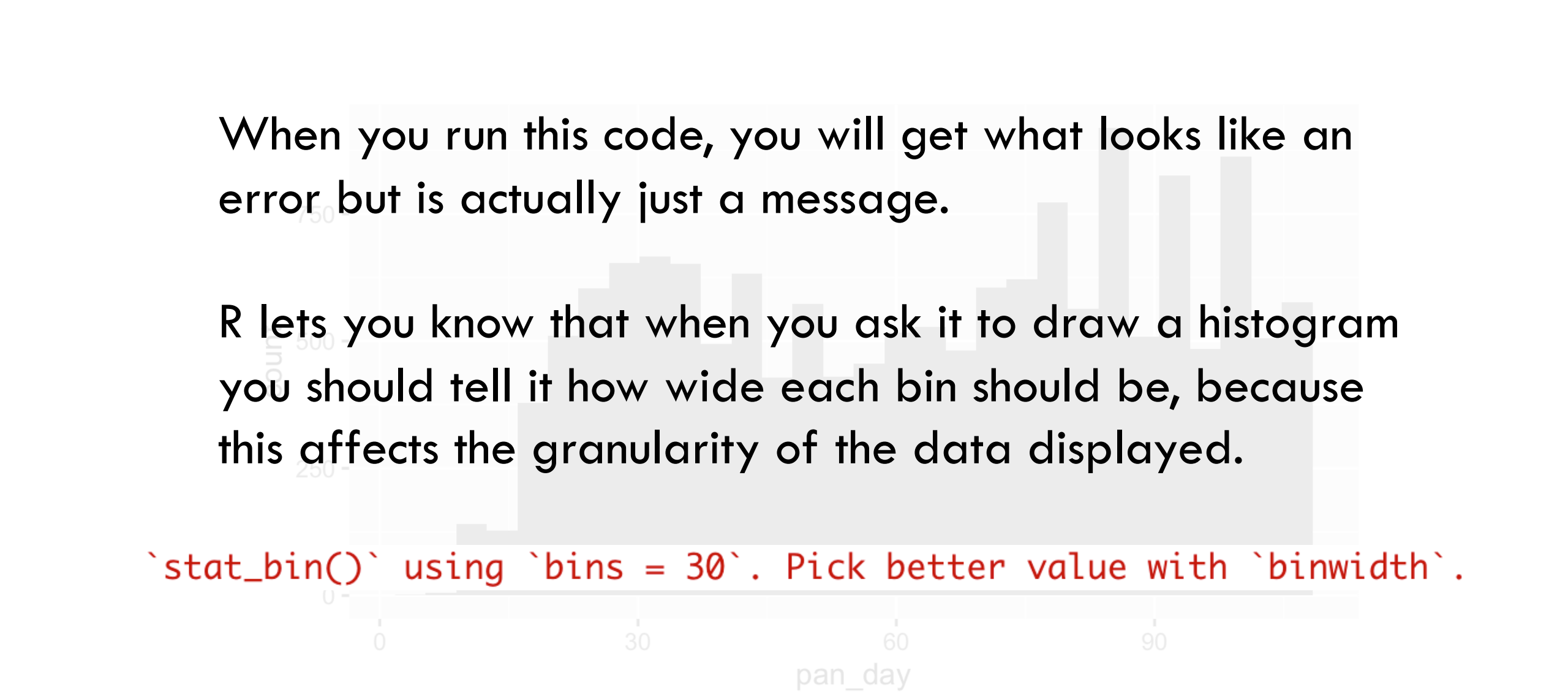
Pay attention to the spelling, capitalization, and parentheses!

```
ggplot(data = covid_testing) +
  geom_histogram(mapping = aes(x = pan_day))
```

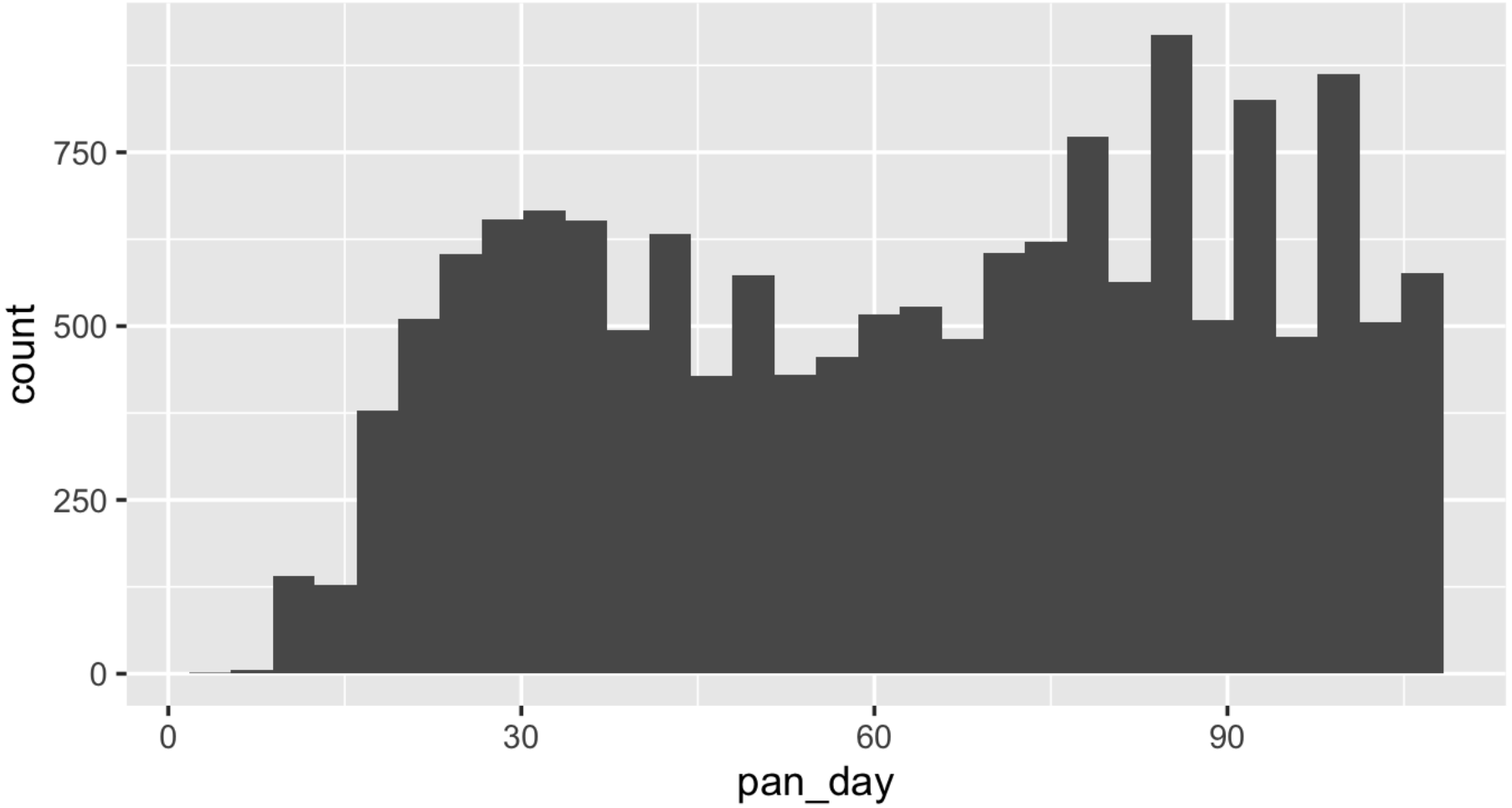
When you run this code, you will get what looks like an error but is actually just a message.

R lets you know that when you ask it to draw a histogram you should tell it how wide each bin should be, because this affects the granularity of the data displayed.

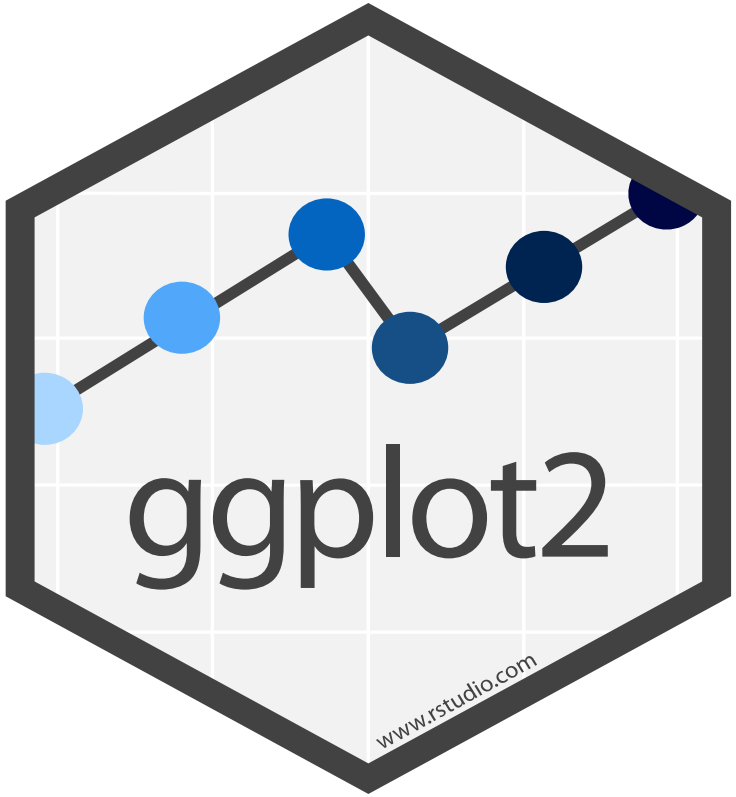
```
`stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```




```
ggplot(data = covid_testing) +
  geom_histogram(mapping = aes(x = pan_day))
```




```
ggplot(data = covid_testing) +
  geom_histogram(mapping = aes(x = pan_day))
```


ggplot2
www.rstudio.com

ggplot()

Always start with ggplot()

data frame

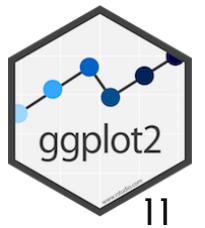
+ sign before new line

```
ggplot(data = covid_testing) +
  geom_histogram(mapping = aes(x = pan_day))
```

type of plot

mappings inside aes() function

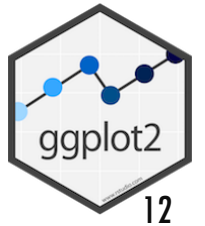
x axis mapping



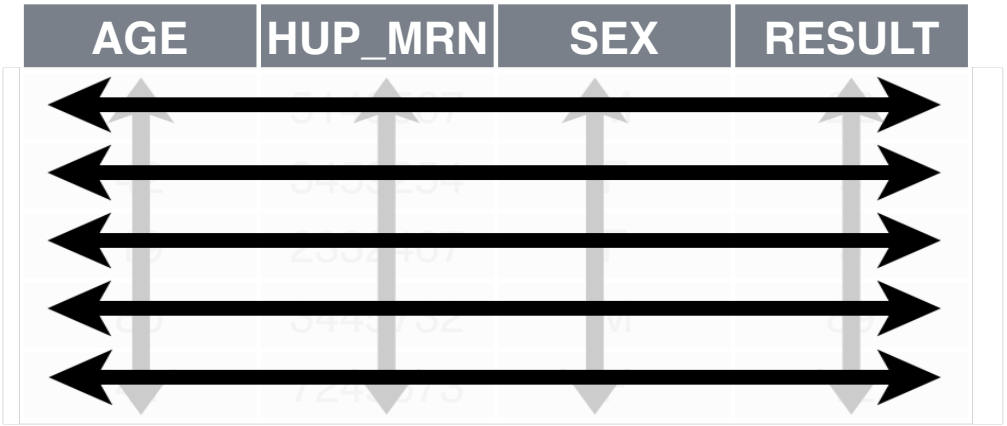
To make **any** kind of graph:

1. Choose a "tidy" **data** frame

```
ggplot(data = data_frame) +
  geom_function(mapping = aes(mappings))
```



1. Pick a "Tidy" Data Frame



A data set is **tidy** if:

1. Each **variable** is in its own **column**
2. Each **observation** is in its own **row**
3. Each **value** is in its own **cell**

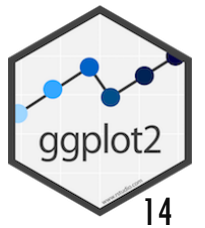
Wickham H. **Tidy Data.** *J Stat Soft* 2014.

To make **any** kind of graph:

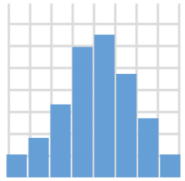
1. Choose a "tidy" **data** frame

```
ggplot(data = data_frame) +
  geom_function(mapping = aes(mappings))
```

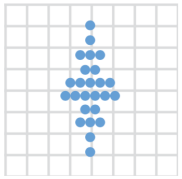
2. Pick a "**geom**" function



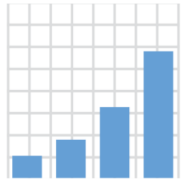
2. Choose a "Geom" Function



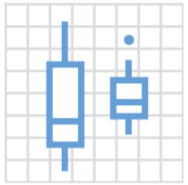
`geom_histogram()`



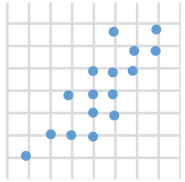
`geom_dotplot()`



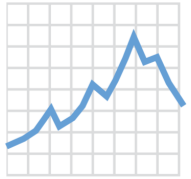
`geom_bar()`



`geom_boxplot()`



`geom_point()`



`geom_line()`

Data Visualization with ggplot2 : : CHEAT SHEET

Basics

ggplot2 is based on the **grammar of graphics**, the idea that you can build every graph from the same components: a **data** set, a **coordinate system**, and geoms—visual marks that represent data points.

To display values, map variables in the data to visual properties of the geom (**aesthetics**) like **size**, **color**, and **x** and **y** locations.

Complete the template below to build a graph.

```
ggplot (data = <DATA>) +                                   ] required
<GEOM_FUNCTION>(mapping = aes(<MAPPINGS>),
 stat = <STAT> , position = <POSITION> ) +                 ] Not required, sensible defaults supplied
<COORDINATE_FUNCTION> +
<FACET_FUNCTION> +
<SCALE_FUNCTION> +
<THEME_FUNCTION>
```

ggplot(data = mpg, **aes**(x = cty, y = hwy)) Begins a plot that you finish by adding layers to. Add one geom function per layer.

aesthetic mappings | data | geom

```
qplot(x = cty, y = hwy, data = mpg, geom = "point")
```

Geoms

Use a geom function to represent data points, use the geom's aesthetic properties to represent variables. Each function returns a layer.

GRAPHICAL PRIMITIVES

```
a <- ggplot(economics, aes(date, unemploy))
b <- ggplot(seals, aes(x = long, y = lat))
```

a + geom_blank()
(Useful for expanding limits)

b + geom_curve(aes(yend = lat + 1, xend=long+1,curvature=z)) - x, xend, y, yend, alpha, angle, color, curvature, linetype, size

a + geom_path(lineend="butt", linejoin="round", linemitre=1)
x, y, alpha, color, group, linetype, size

a + geom_polygon(aes(group = group))
x, y, alpha, color, fill, group, linetype, size

b + geom_rect(aes(xmin = long, ymin=lat, xmax= long + 1, ymax = lat + 1)) - xmax, xmin, ymax, ymin, alpha, color, fill, linetype, size

a + geom_ribbon(aes(ymin=unemploy - 900, ymax=unemploy + 900)) - x, ymax, ymin, alpha, color, fill, group, linetype, size

LINE SEGMENTS

common aesthetics: x, y, alpha, color, linetype, size

b + geom_abline(aes(intercept=0, slope=1))
b + geom_hline(aes(yintercept = lat))
b + geom_vline(aes(xintercept = long))

b + geom_segment(aes(yend=lat+1, xend=long+1))
b + geom_spoke(aes(angle = 1:1155, radius = 1))

ONE VARIABLE continuous

```
c <- ggplot(mpg, aes(hwy)); c2 <- ggplot(mpg)
```

c + geom_area(stat = "bin")
x, y, alpha, color, fill, linetype, size

c + geom_density(kernel = "gaussian")
x, y, alpha, color, fill, group, linetype, size, weight

c + geom_dotplot()
x, y, alpha, color, fill

TWO VARIABLES

continuous x , continuous y

```
e <- ggplot(mpg, aes(cty, hwy))
```

e + geom_label(aes(label = cty), nudge_x = 1, nudge_y = 1, check_overlap = TRUE) x, y, label, alpha, angle, color, family, fontface, hjust, lineheight, size, vjust

e + geom_jitter(height = 2, width = 2)
x, y, alpha, color, fill, shape, size

e + geom_point(), x, y, alpha, color, fill, shape, size, stroke

e + geom_quantile(), x, y, alpha, color, group, linetype, size, weight

e + geom_rug(sides = "bl"), x, y, alpha, color, linetype, size

e + geom_smooth(method = lm), x, y, alpha, color, fill, group, linetype, size, weight

e + geom_text(aes(label = cty), nudge_x = 1, nudge_y = 1, check_overlap = TRUE), x, y, label, alpha, angle, color, family, fontface, hjust, lineheight, size, vjust

discrete x , continuous y

```
f <- ggplot(mpg, aes(class, hwy))
```

f + geom_col(), x, y, alpha, color, fill, group, linetype, size

f + geom_boxplot(), x, y, lower, middle, upper, ymax, ymin, alpha, color, fill, group, linetype, shape, size, weight

f + geom_dotplot(binaxis = "y", stackdir = "center"), x, y, alpha, color, fill, group

f + geom_violin(scale = "area"), x, y, alpha, color, fill, group, linetype, size, weight

continuous bivariate distribution

```
h <- ggplot(diamonds, aes(carat, price))
```

h + geom_bin2d(binwidth = c(0.25, 500))
x, y, alpha, color, fill, linetype, size, weight

h + geom_density2d()
x, y, alpha, colour, group, linetype, size

h + geom_hex()
x, y, alpha, colour, fill, size

continuous function

```
i <- ggplot(economics, aes(date, unemploy))
```

i + geom_area()
x, y, alpha, color, fill, linetype, size

i + geom_line()
x, y, alpha, color, group, linetype, size

i + geom_step(direction = "hv")
x, y, alpha, color, group, linetype, size

visualizing error

```
df <- data.frame(grp = c("A", "B"), fit = 4:5, se = 1:2)
j <- ggplot(df, aes(grp, fit, ymin = fit-se, ymax = fit+se))
```

j + geom_crossbar(fatten = 2)
x, y, ymax, ymin, alpha, color, fill, group, linetype, size

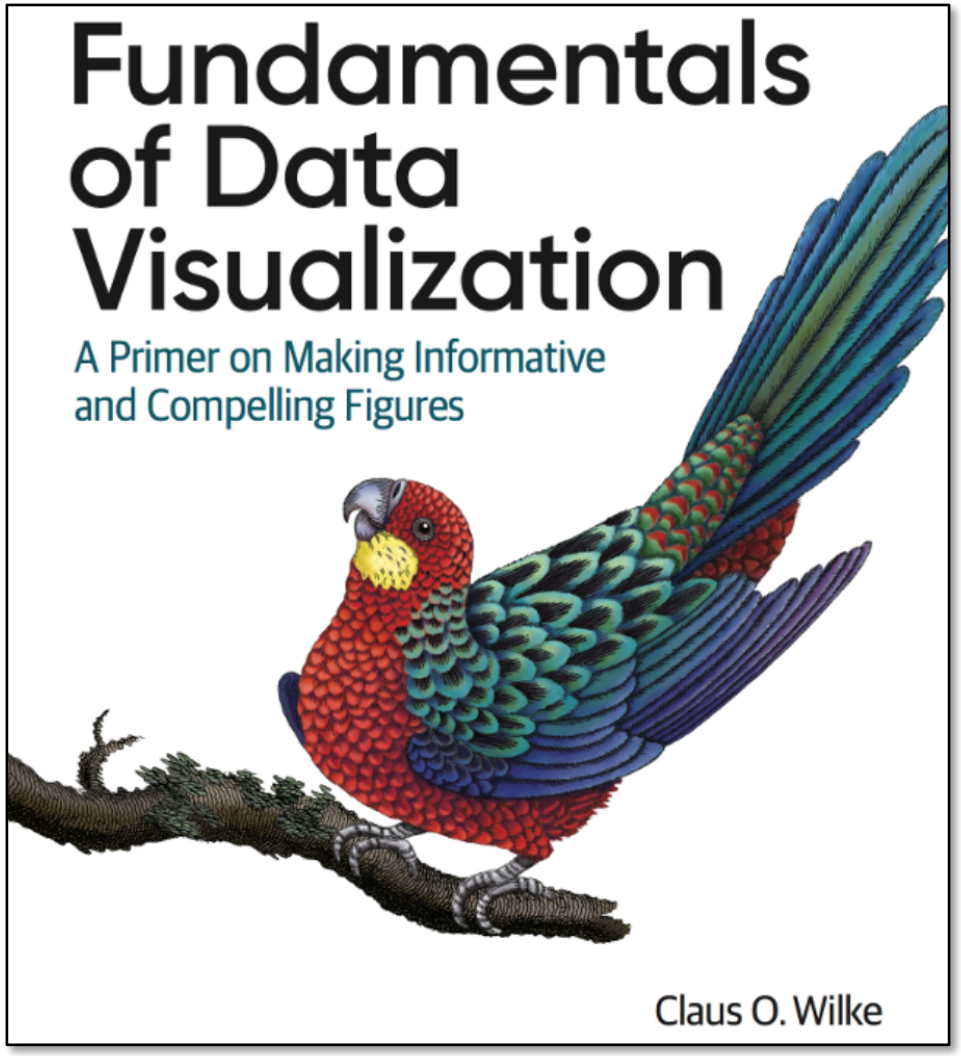
j + geom_errorbar(), x, ymax, ymin, alpha, color, group, linetype, size, width (also **geom_errorbarh()**)

j + geom_linerange()
x, ymin, ymax, alpha, color, group, linetype, size

j + geom_pointrange()
x, y, ymin, ymax, alpha, color, fill, group, linetype, shape, size

maps

```
data <- data.frame(murder = USArrests$Murder
```



https://serialmentor.com/dataviz

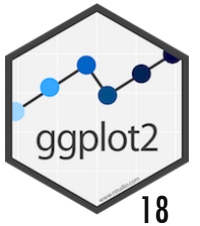
To make **any** kind of graph:

1. Choose a "tidy" **data** frame

```
ggplot(data = data_frame) +
  geom_function(mapping = aes(mappings))
```

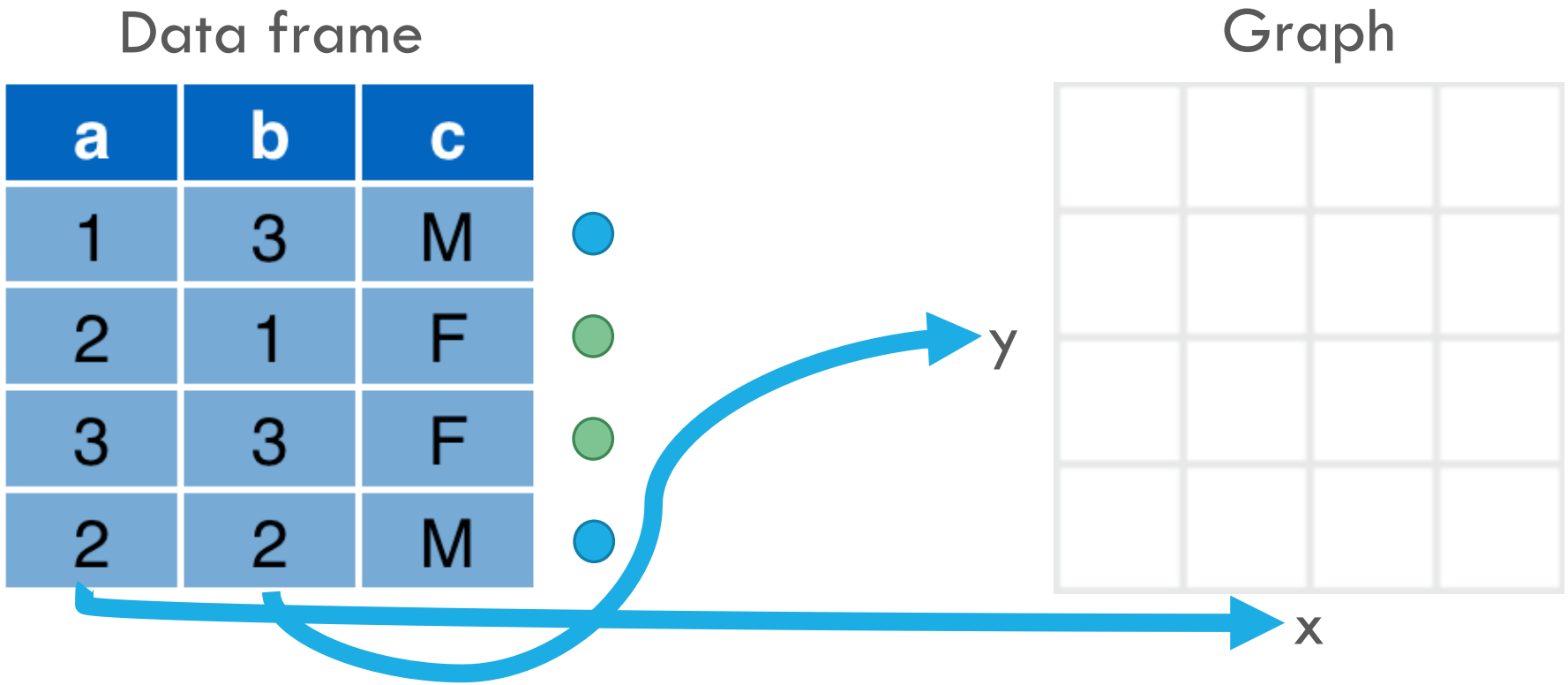
2. Pick a "**geom**" function

3. Write aesthetic **mappings**

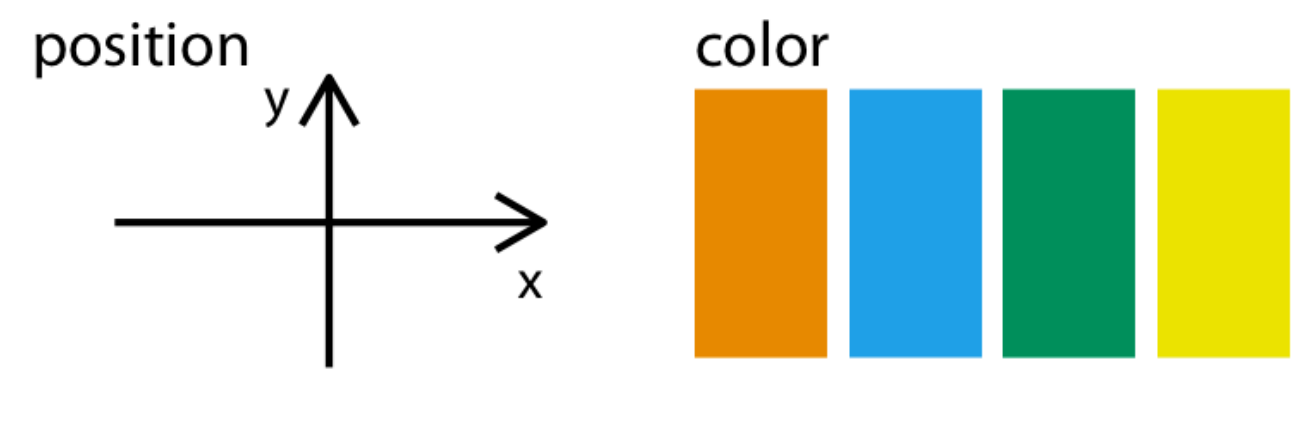


3. Write Aesthetic Mappings

```
aes(x = a, y = b, color = c)
```



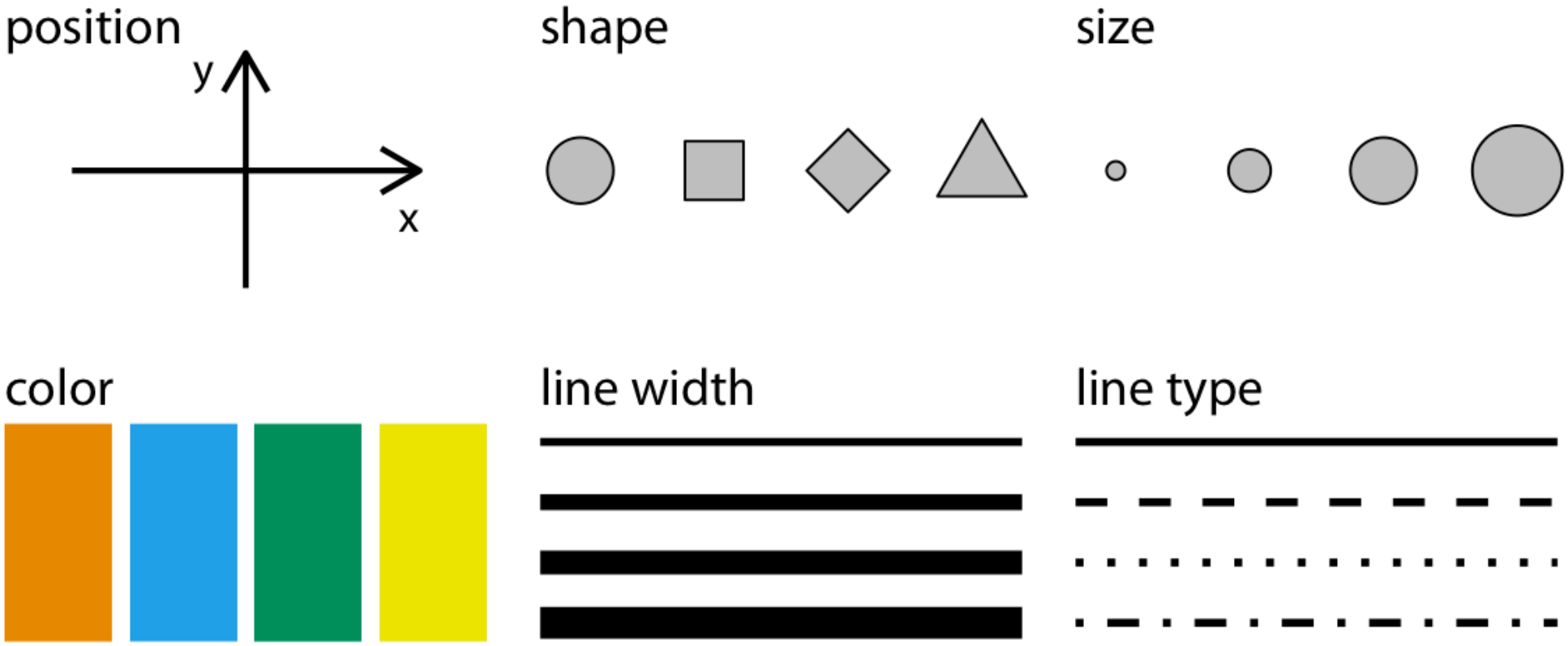
Your Turn 4



In addition to x/y position and color, what other aesthetics can you think of?

Type your answers in the chat!

Aesthetics



From Fundamentals of Data Visualization, by Claus Wilke, licensed under CC-BY-NC-ND

To make **any** kind of graph:

1. Choose a "tidy" **data** frame

```
ggplot(data = data_frame) +
  geom_function(mapping = aes(mappings))
```

2. Pick a "**geom**" function

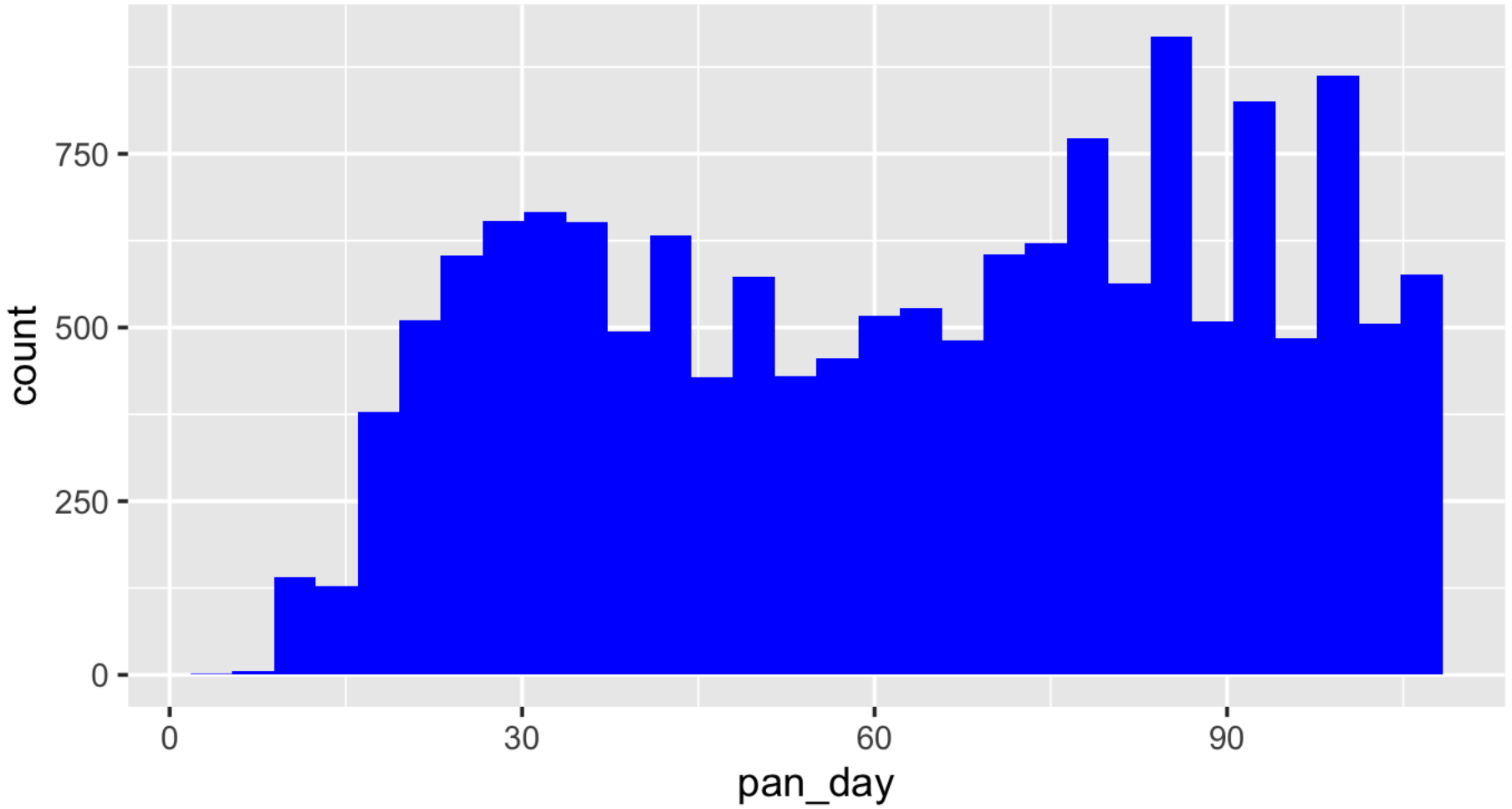
3. Write aesthetic **mappings**

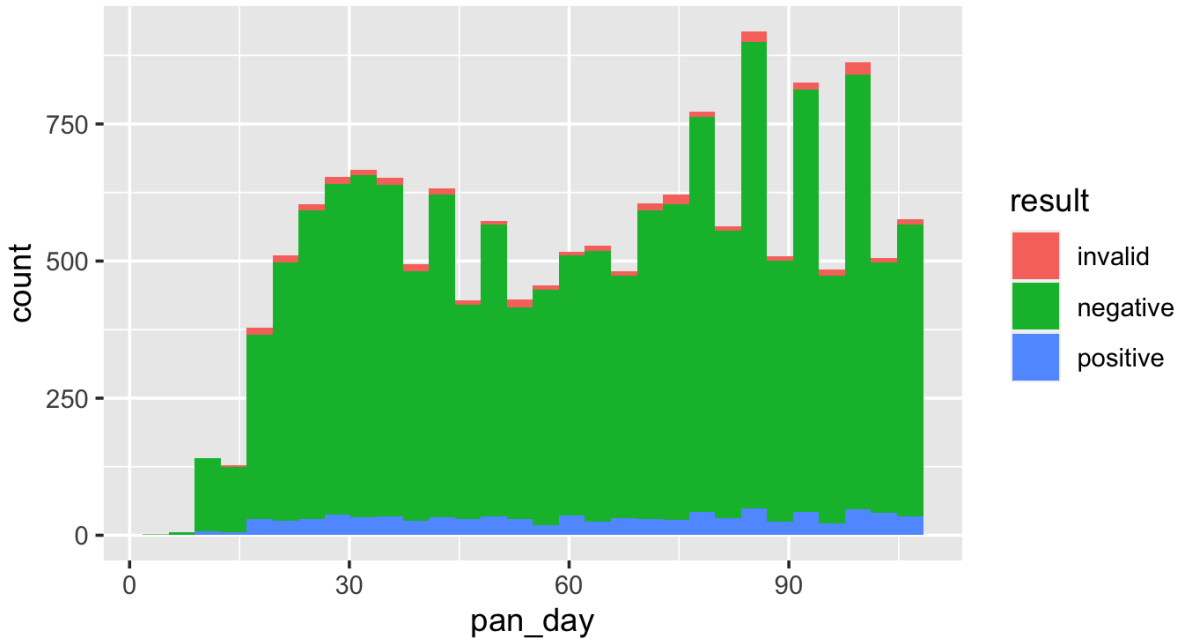
Your Turn 5

Open `03-Visualize.Rmd`. Work through the exercises of the section titled "Your Turn 5."

Setting vs Mapping Aesthetics

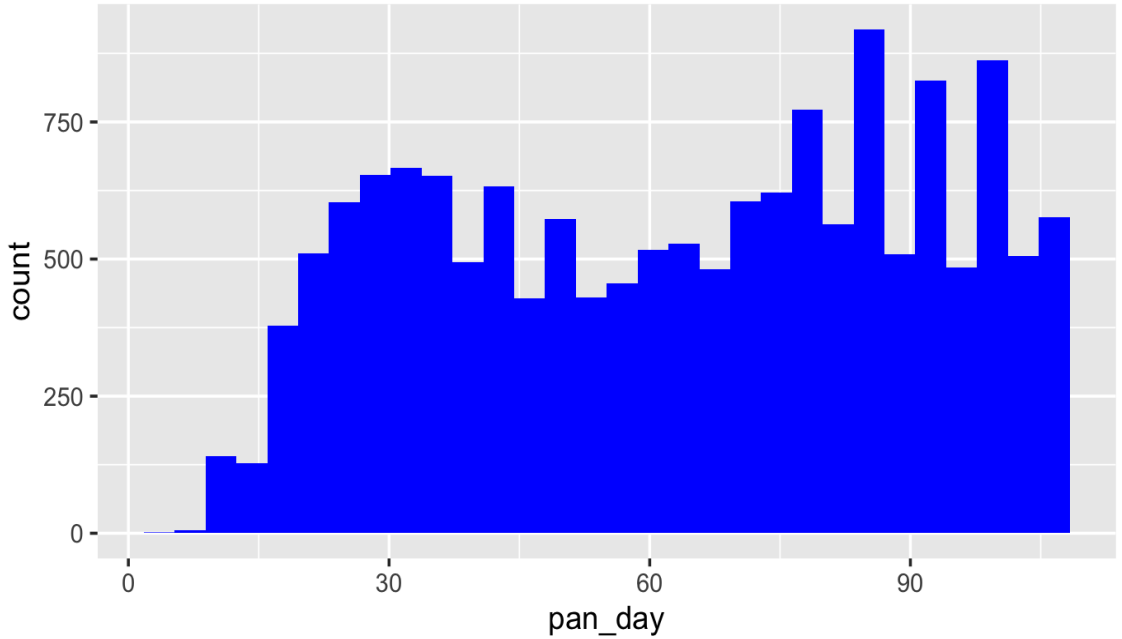
How would you make this plot?





Inside of aes():
map an aesthetic
to a variable

```
ggplot(data = covid_testing) +
  geom_histogram(mapping = aes(x = pan_day, fill = result))
```

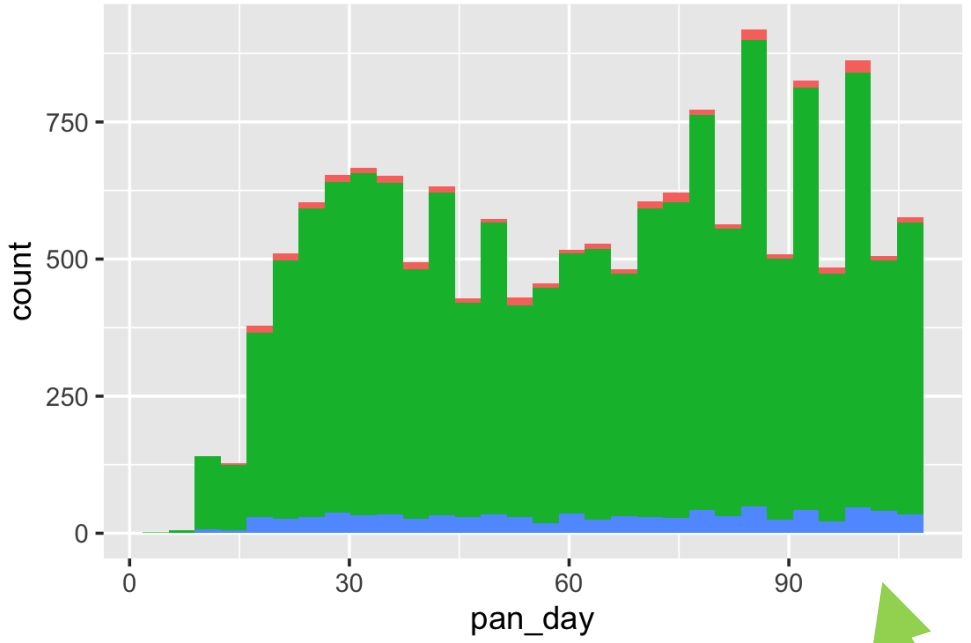


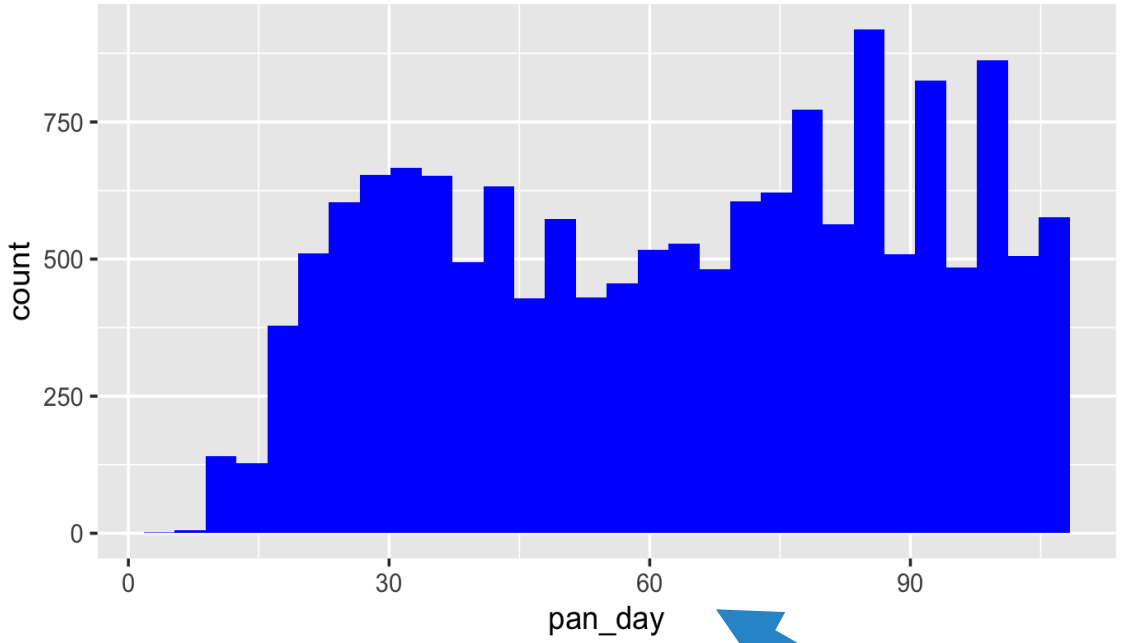
Outside of **aes()**:

set an aesthetic to a **value**

color name in "quotes"

```
ggplot(data = covid_testing) +
  geom_histogram(mapping = aes(x = pan_day), fill = "blue")
```



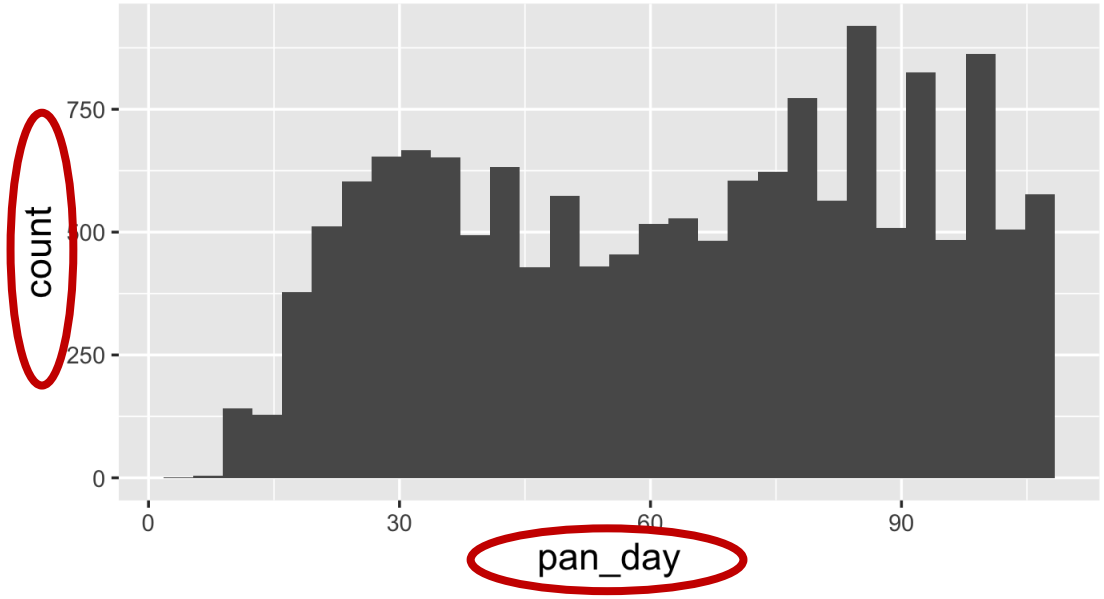


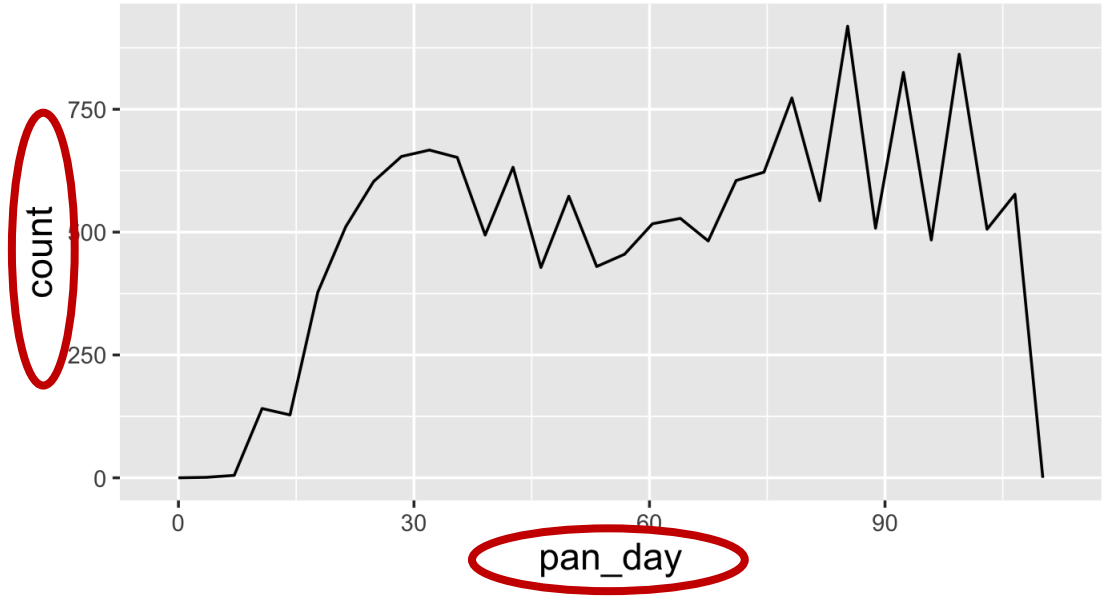

```
ggplot(data = covid_testing) +
  geom_histogram(mapping = aes(x = pan_day, fill = result))
```

```
ggplot(data = covid_testing) +
  geom_histogram(mapping = aes(x = pan_day), fill = "blue")
```

Geom Functions

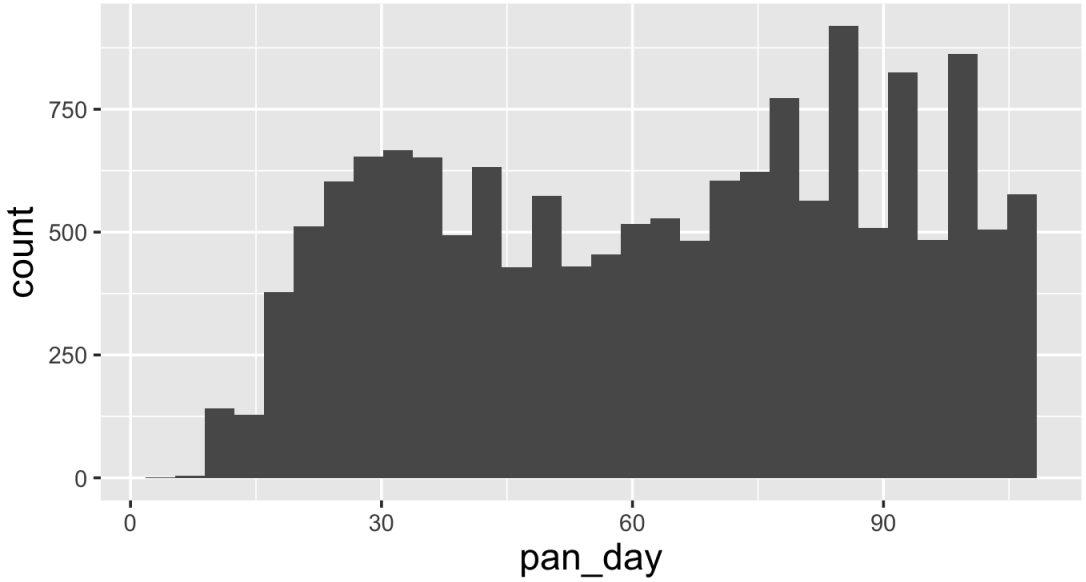
How are these plots similar?

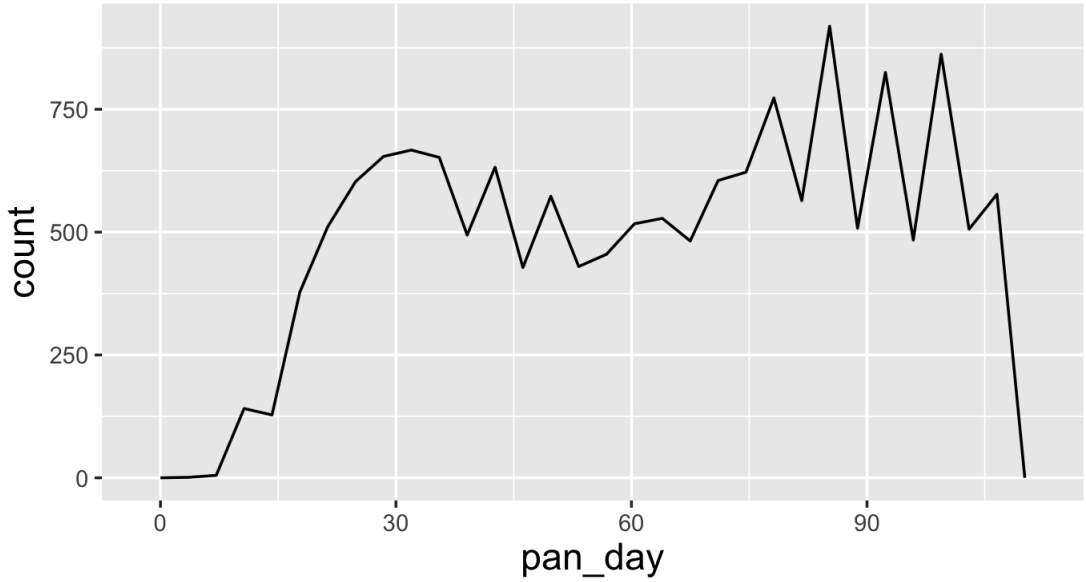




Same: x axis, y axis, data

How are these plots different?



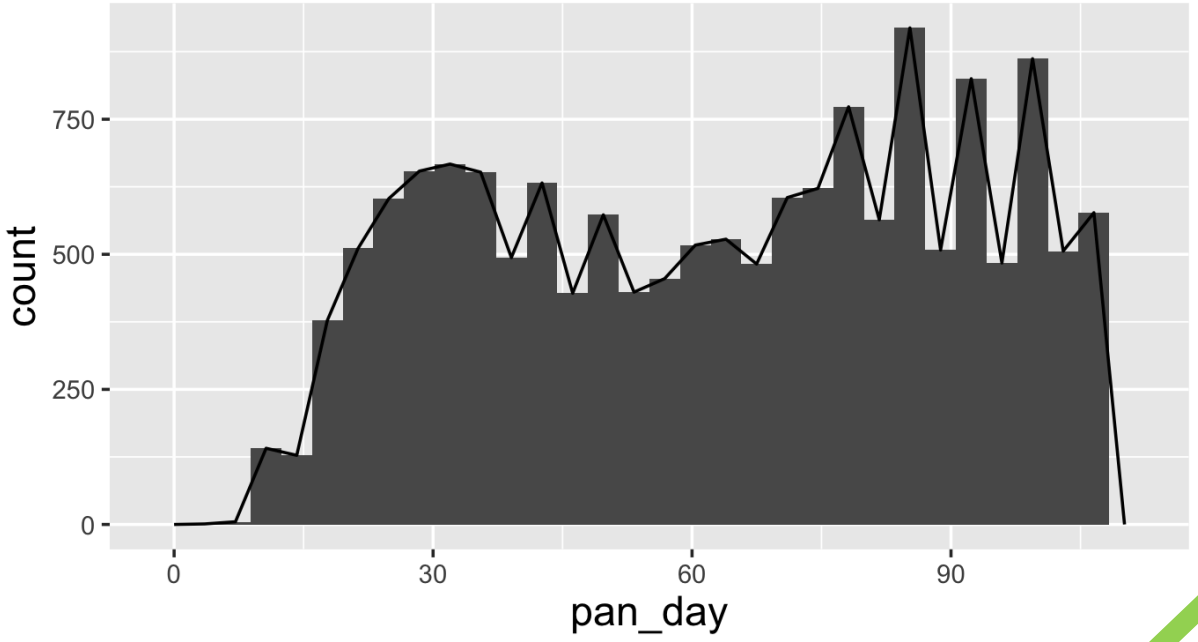


Different **geometric object** ("geom") used to represent the data

Your Turn 6

Open `03-Visualize.Rmd`. Work through the exercises of the section titled "Your Turn 6."

Global vs Local Settings



Inside of geom_ function: apply locally to only the current layer

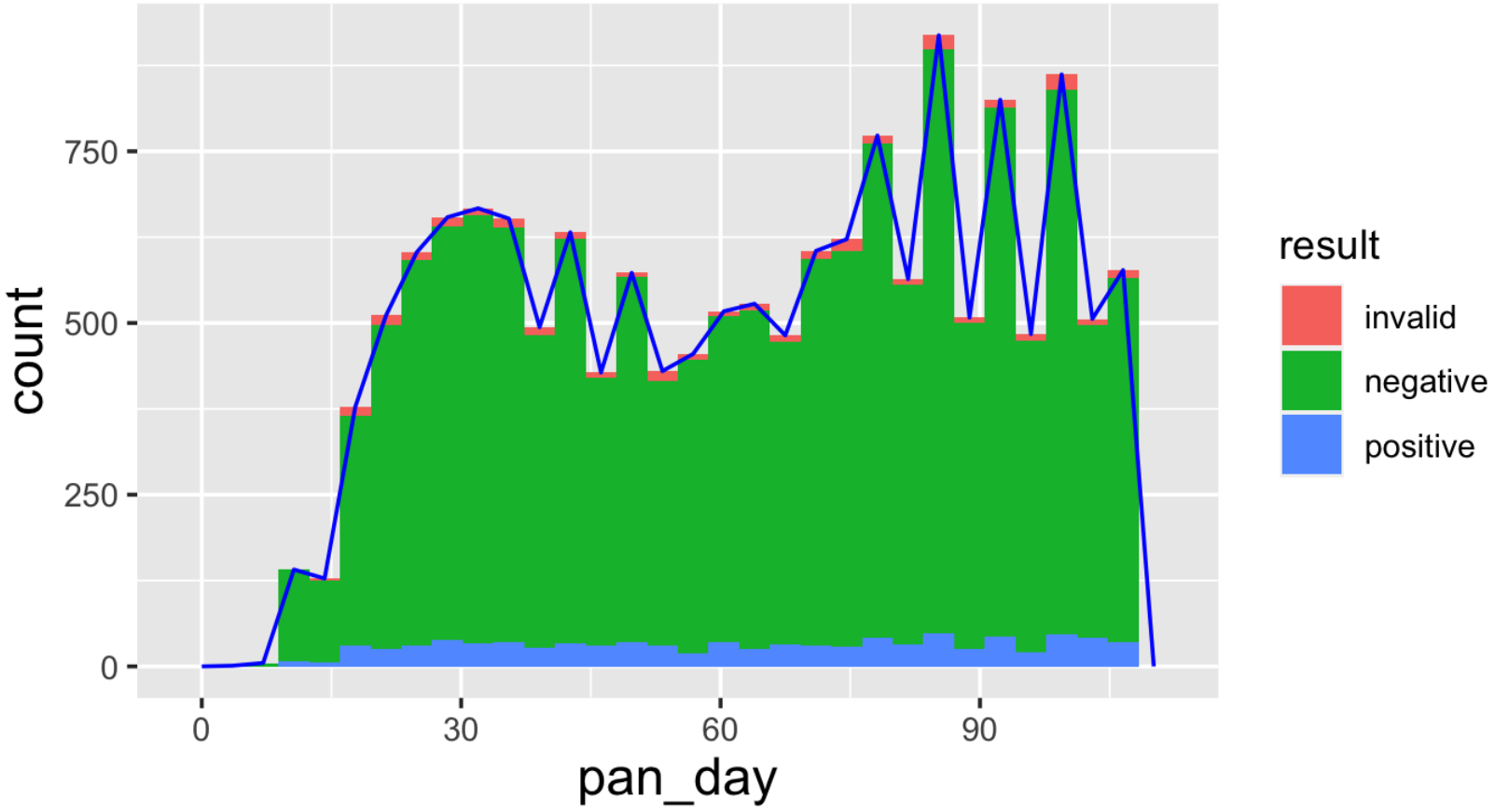
Inside of ggplot(): apply globally to every layer

```
ggplot(data = covid_testing) +
  geom_histogram(mapping = aes(x = pan_day)) +
  geom_freqpoly(mapping = aes(x = pan_day))
```

```
ggplot(data = covid_testing, mapping = aes(x = pan_day)) +
  geom_histogram() +
  geom_freqpoly()
```

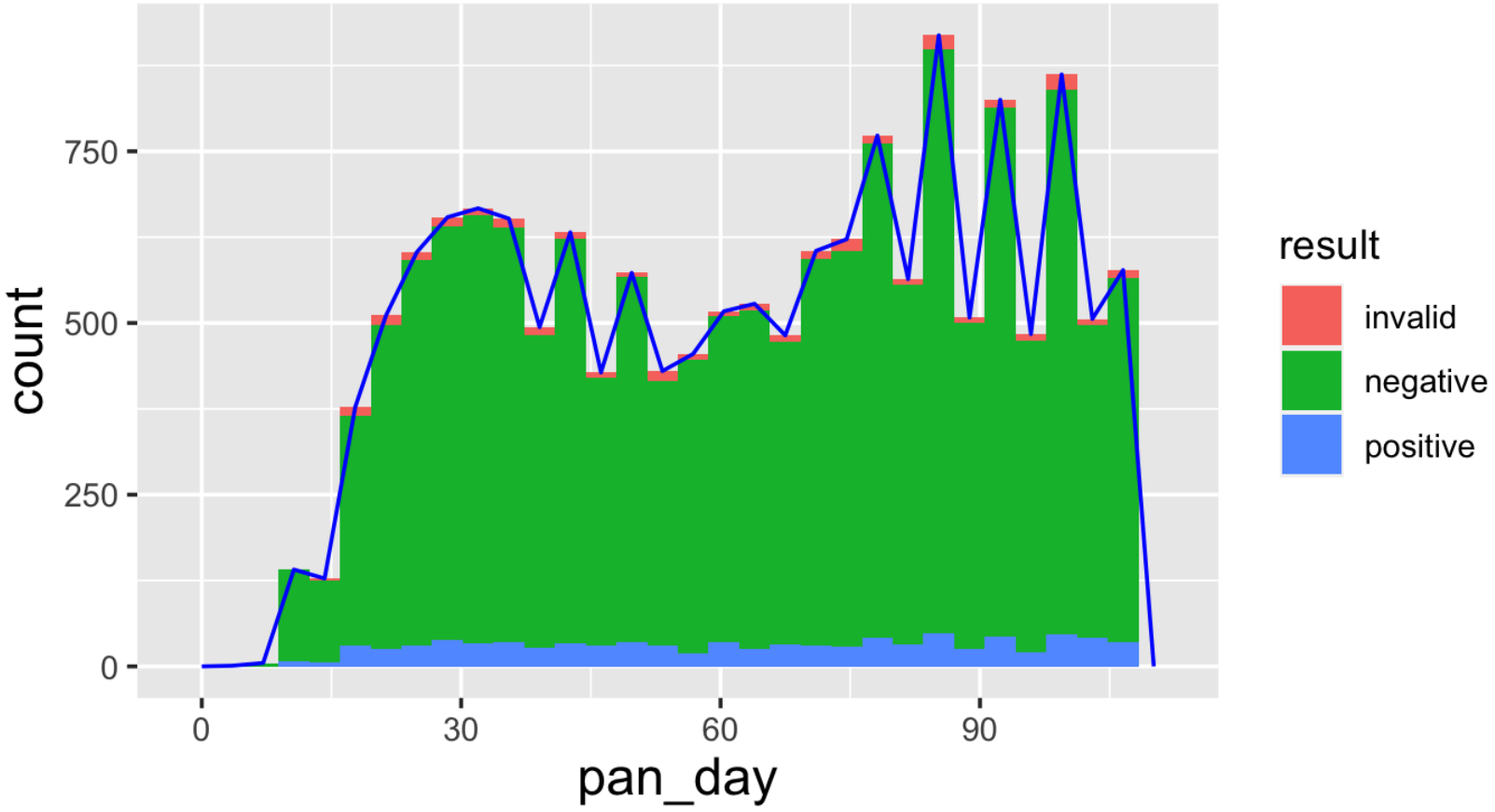
empty ()

How would you make this plot?



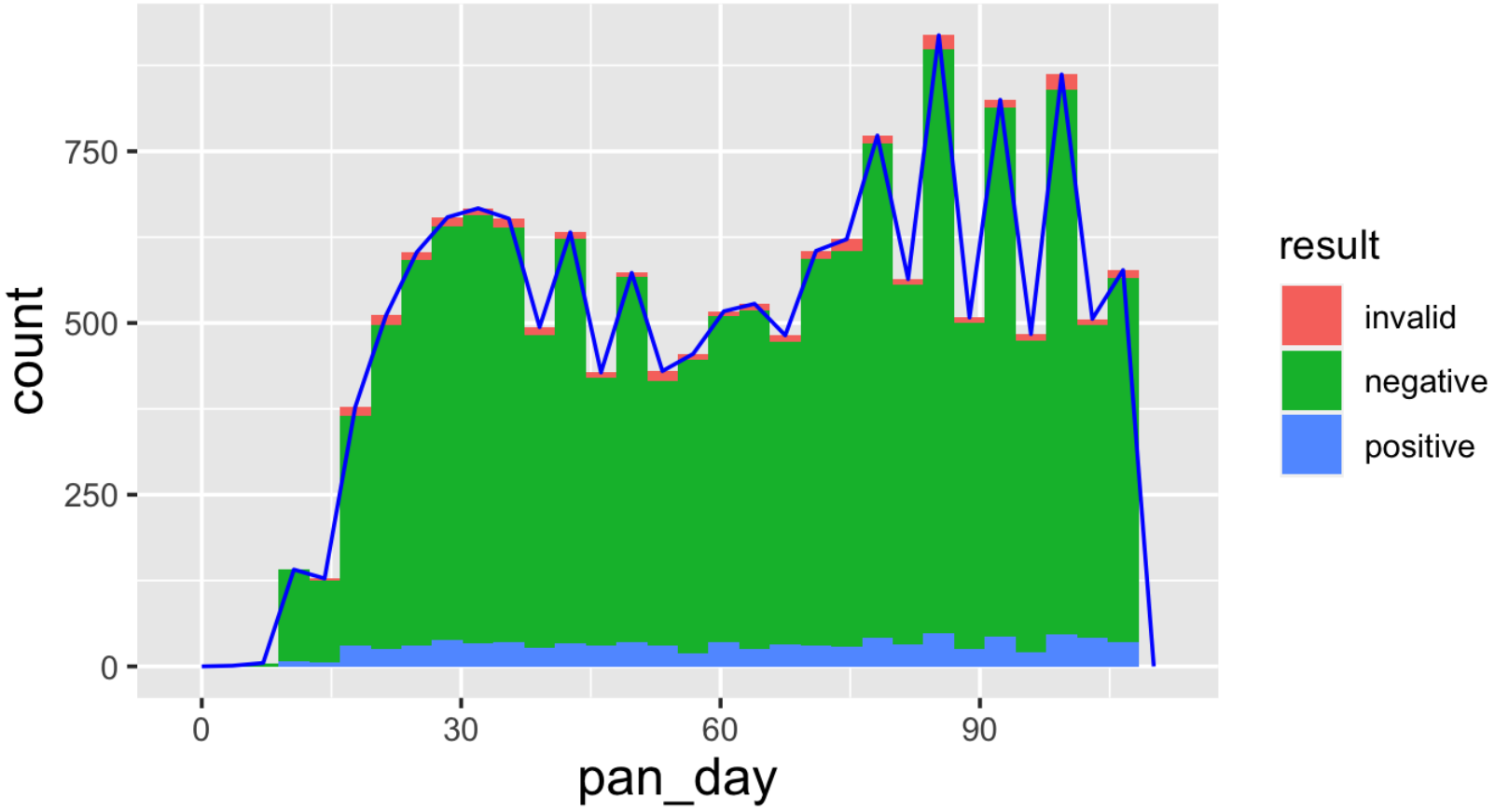

```
ggplot(
```

How would you make this plot?



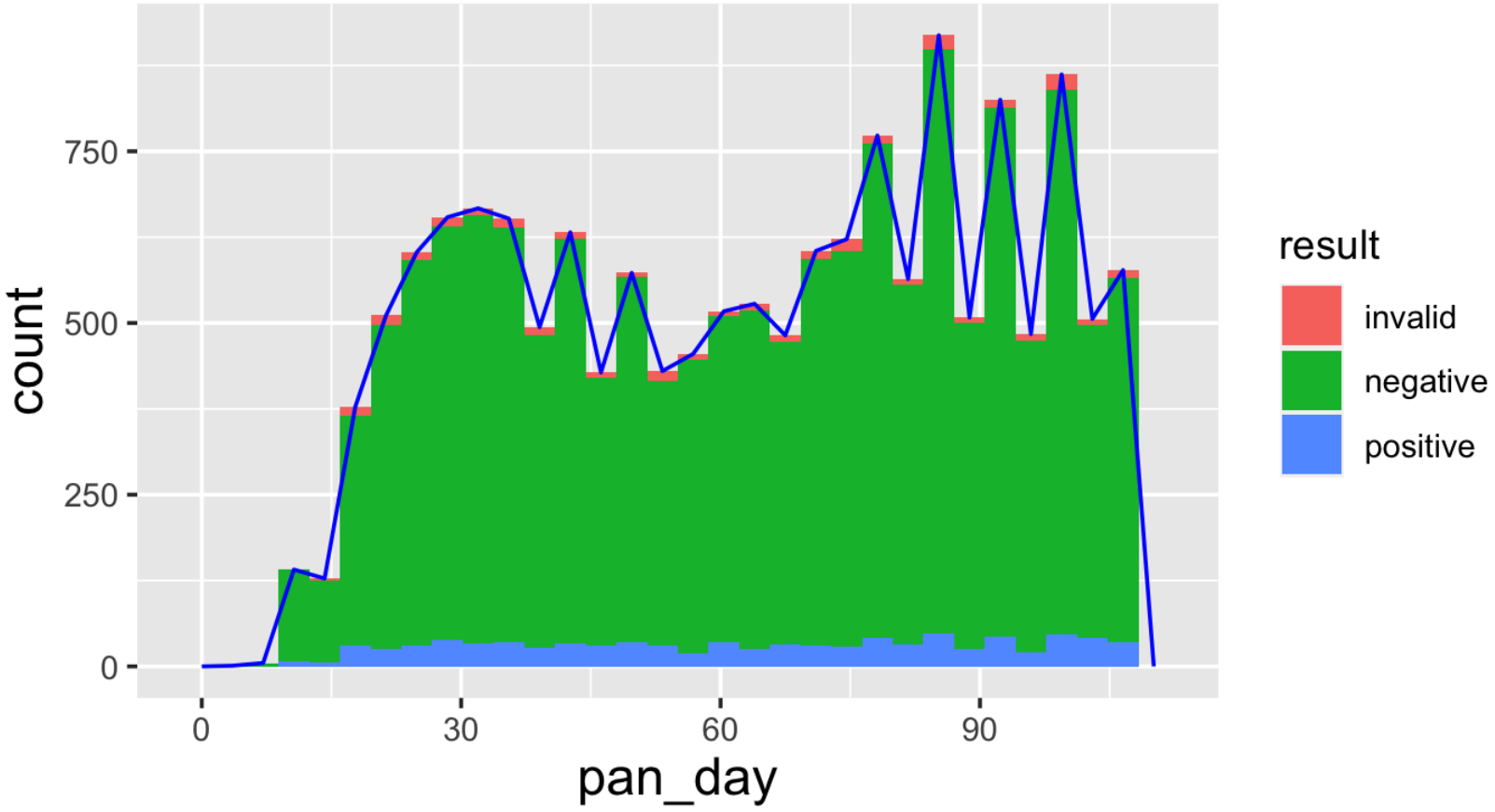

```
ggplot(data = covid_testing
```

How would you make this plot?



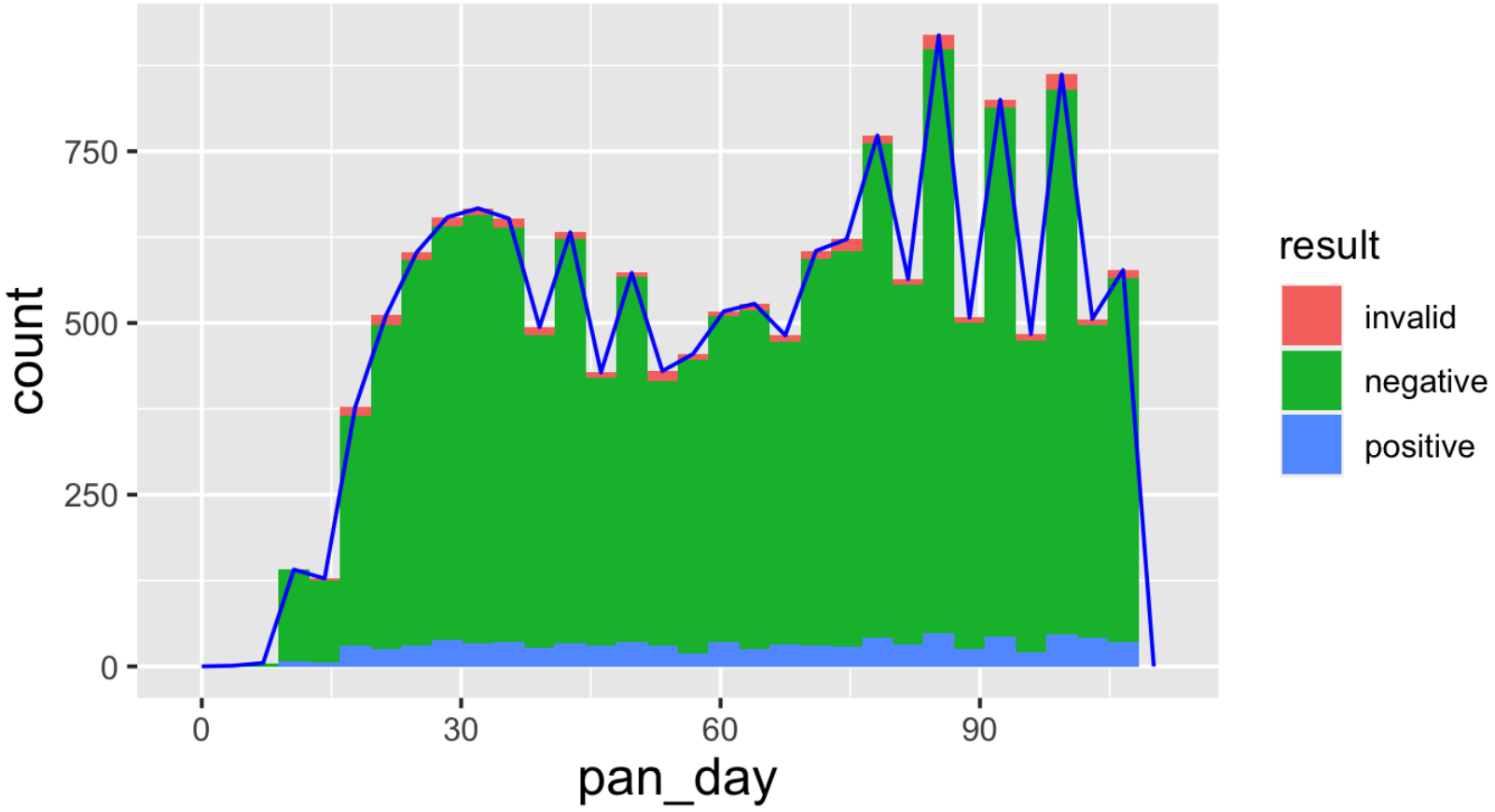

```
ggplot(data = covid_testing, mapping = aes(x = pan_day)) +
  geom_histogram(
```

How would you make this plot?




```
ggplot(data = covid_testing, mapping = aes(x = pan_day)) +
  geom_histogram(mapping = aes(fill = result)) +
  geom_freqpoly(
```

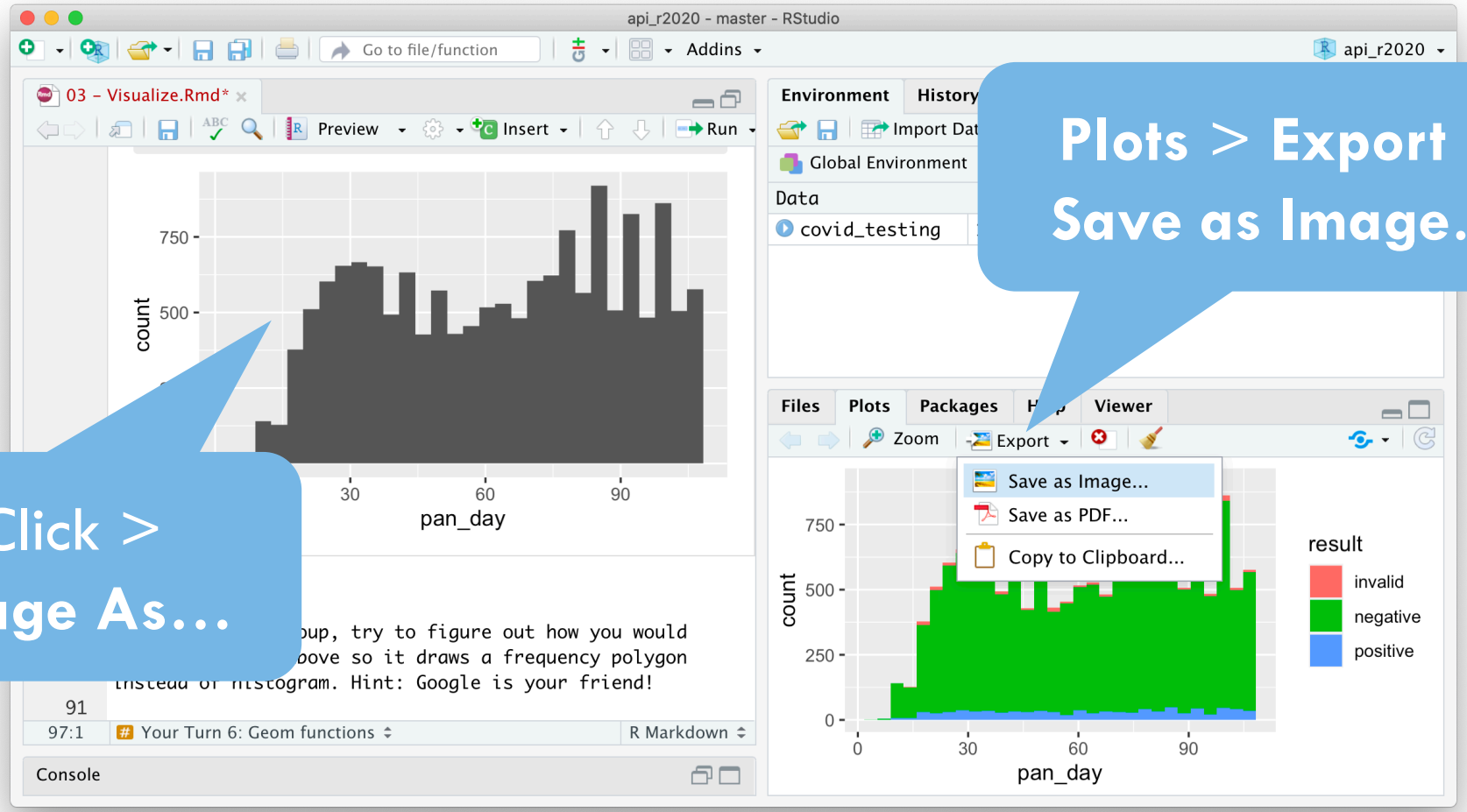
How would you make this plot?




```
ggplot(data = covid_testing, mapping = aes(x = pan_day)) +
  geom_histogram(mapping = aes(fill = result)) +
  geom_freqpoly(color = "blue")
```

What Else?

Manually saving plots

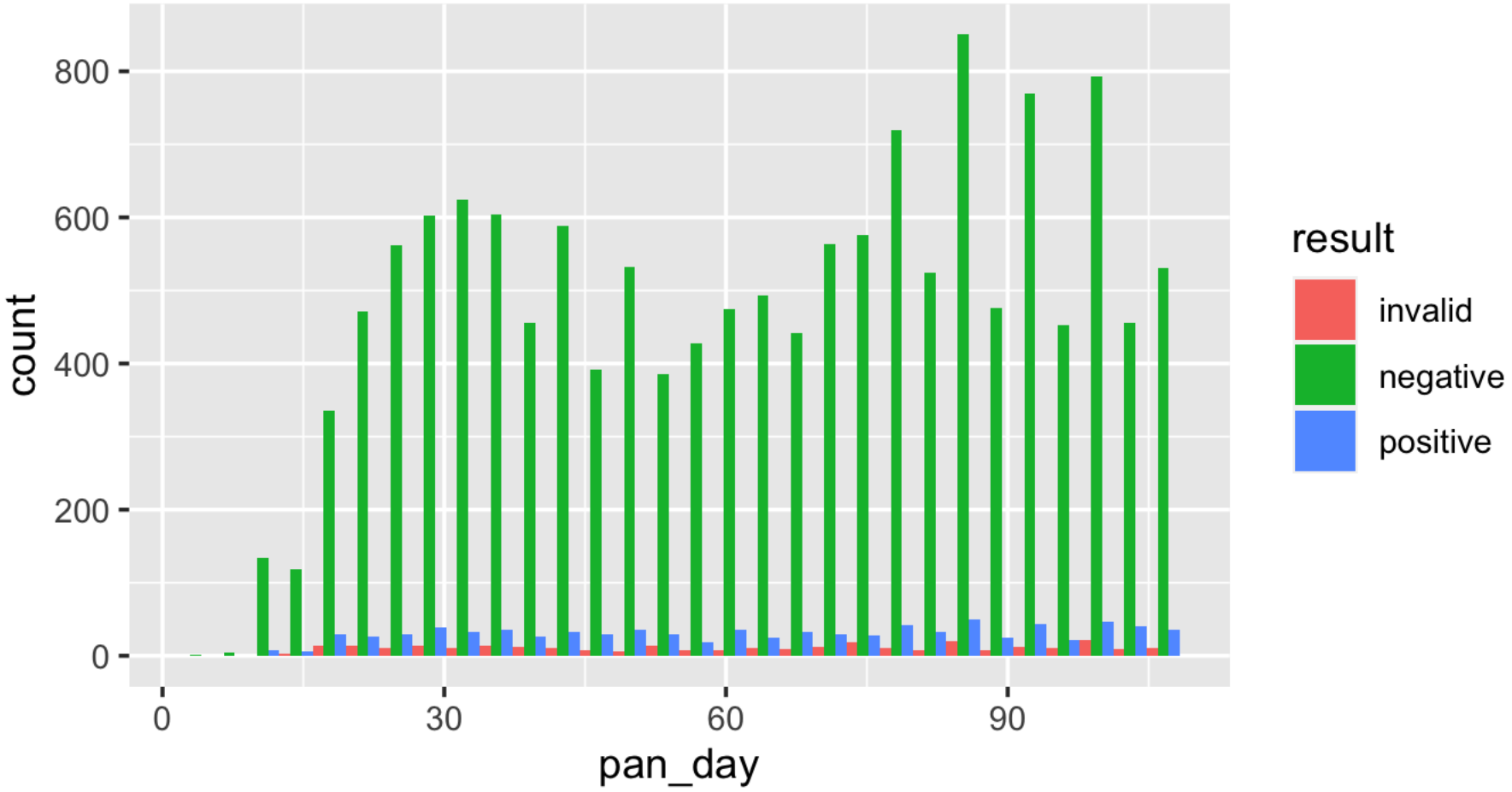


Right Click > **Save Image As...**

Plots > Export > Save as Image...

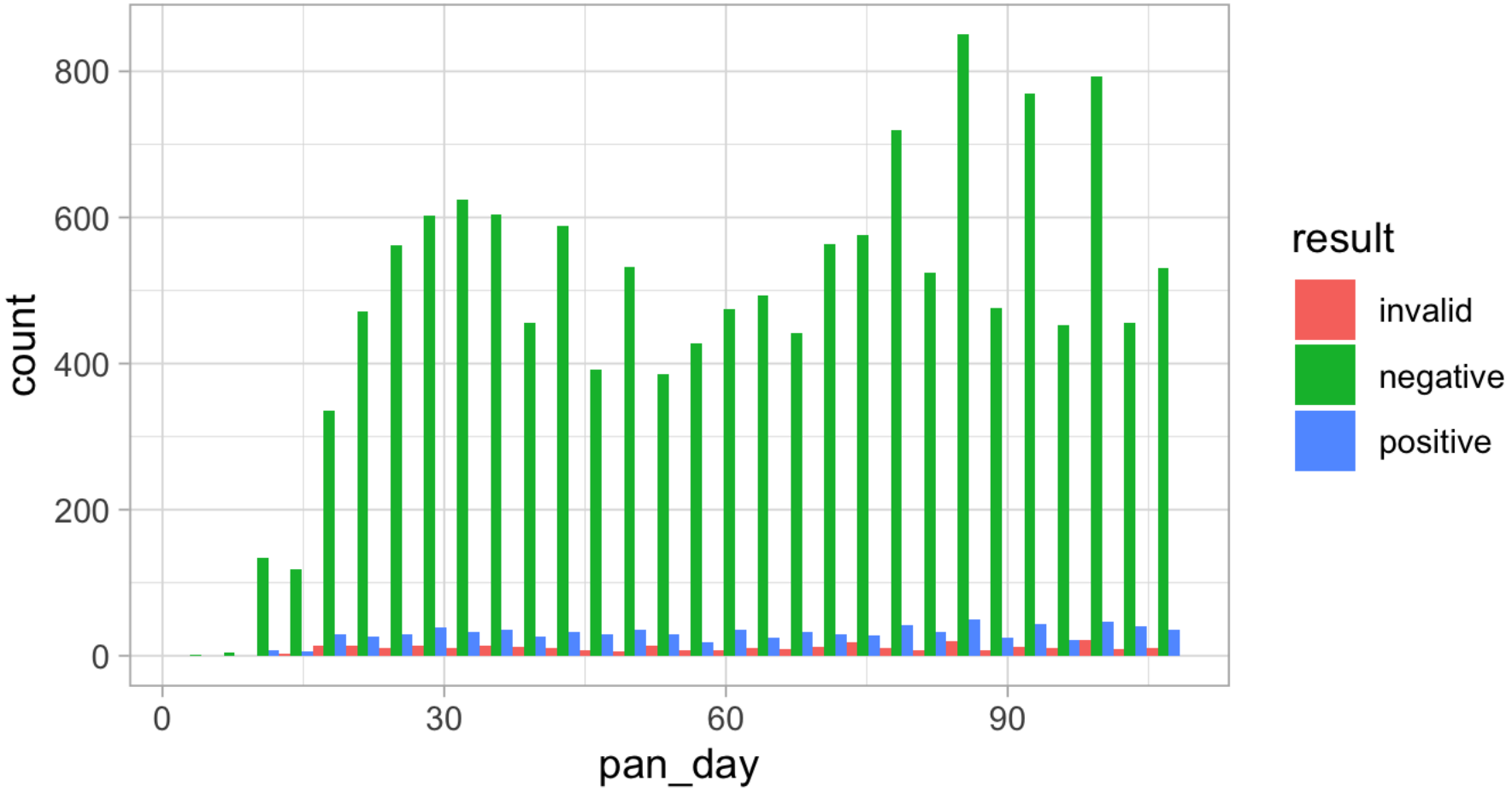
Position adjustments

How overlapping objects are arranged



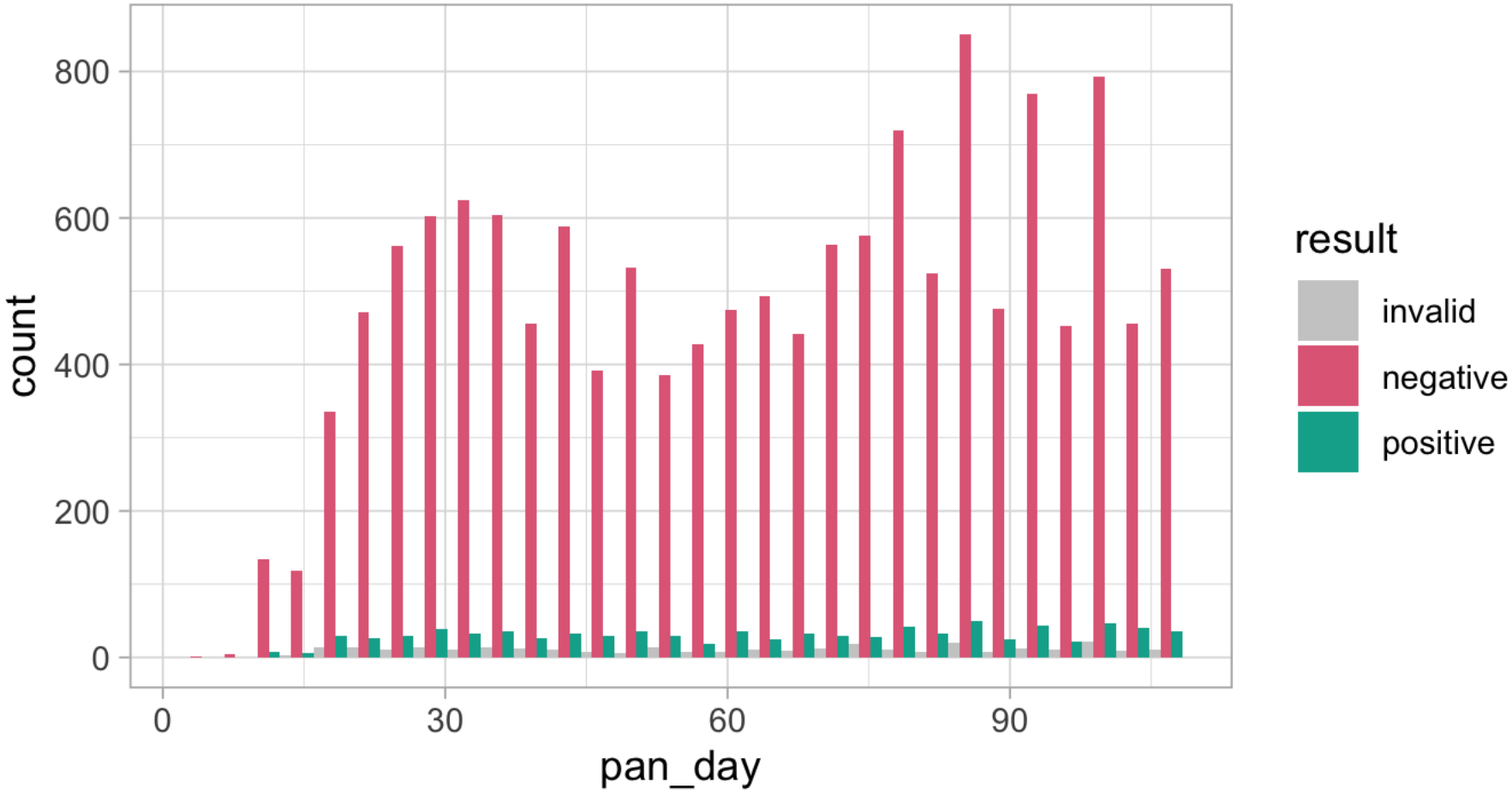
Themes

Visual appearance of non-data elements



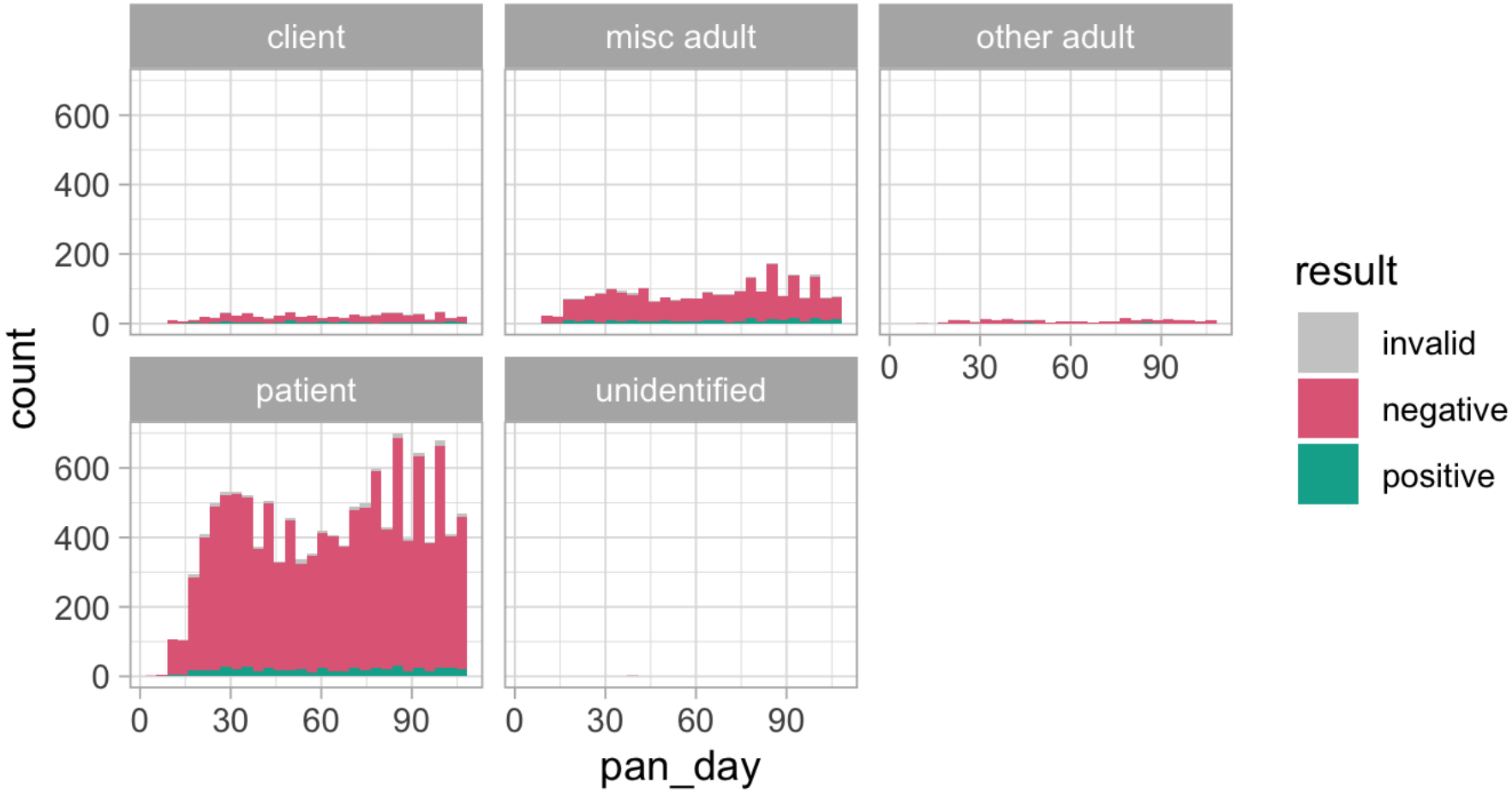
Scales

Customize color scales and other mappings

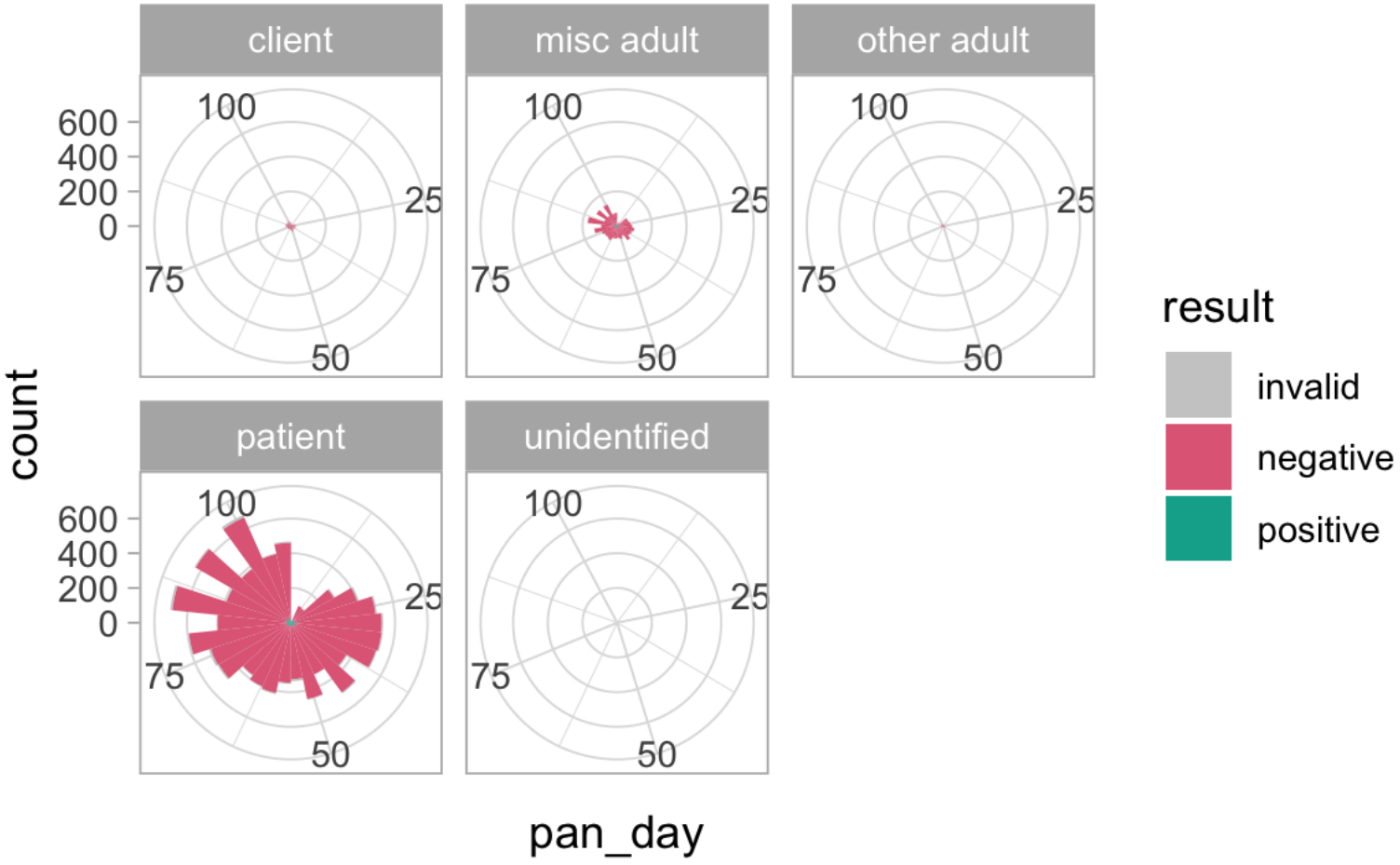


Facets

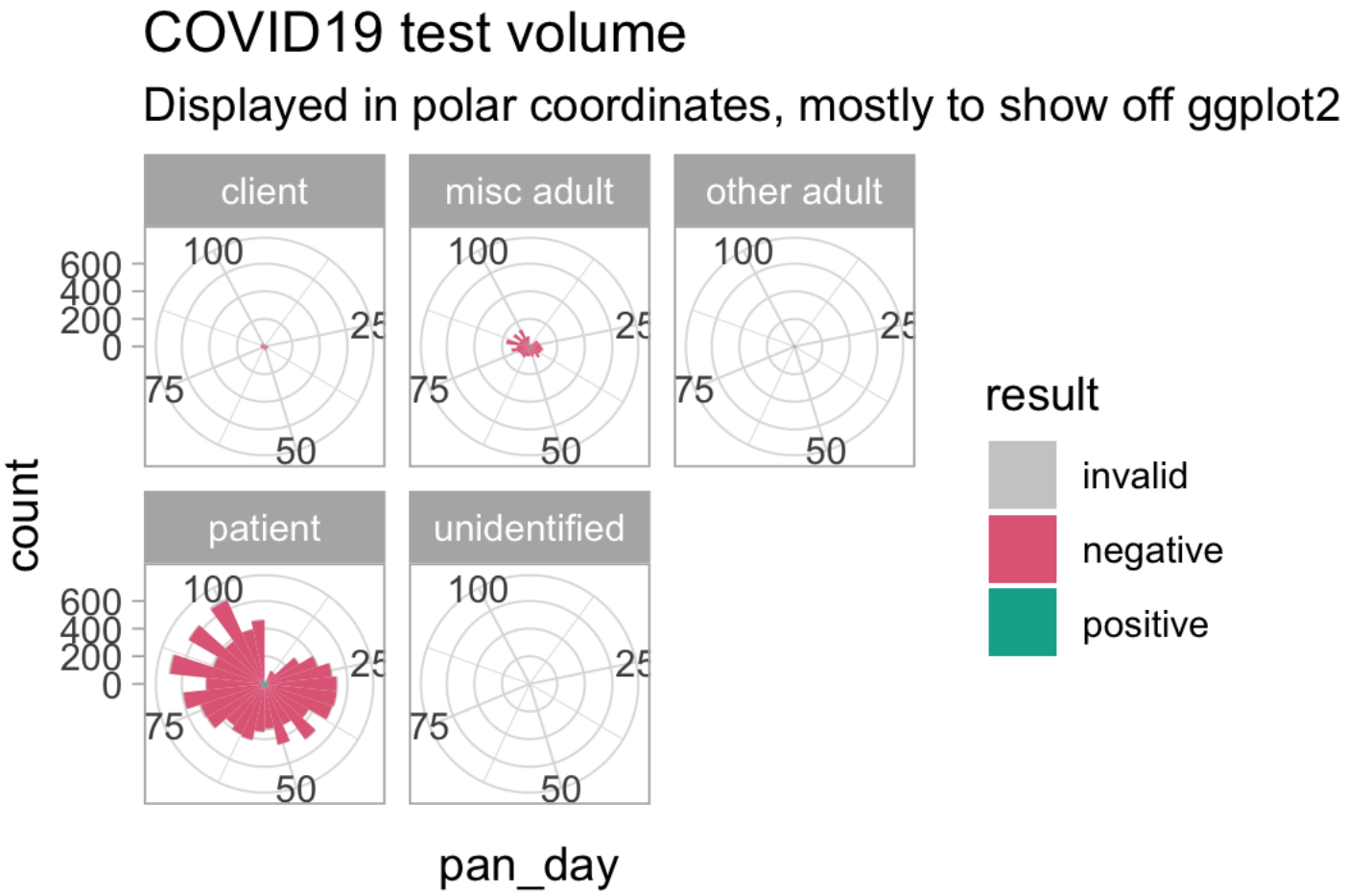
Subplots that display subsets of the data



Coordinate systems



Titles and captions



```
ggplot(data = data_frame) +
  geom_function(mapping = aes(mappings)) +
  theme_function +
  scale_function +
  facet_function +
  coordinate_function +
  ...
```

Required

Optional

Goals

1. Appreciate the importance of visualization for understanding data
2. Learn how to use ggplot2 to visualize data

Objectives

1. Create a basic visualization using a simple **template**
2. Define "**aesthetic mapping**" and explain how aesthetic mappings relate variables of a data frame to features of graphic markings on a plot
3. Write the code to specify a type of plot and fine tune its appearance using "**geom**" functions
4. Explain how to add **layers** to a ggplot object to create complex and highly customized visualizations