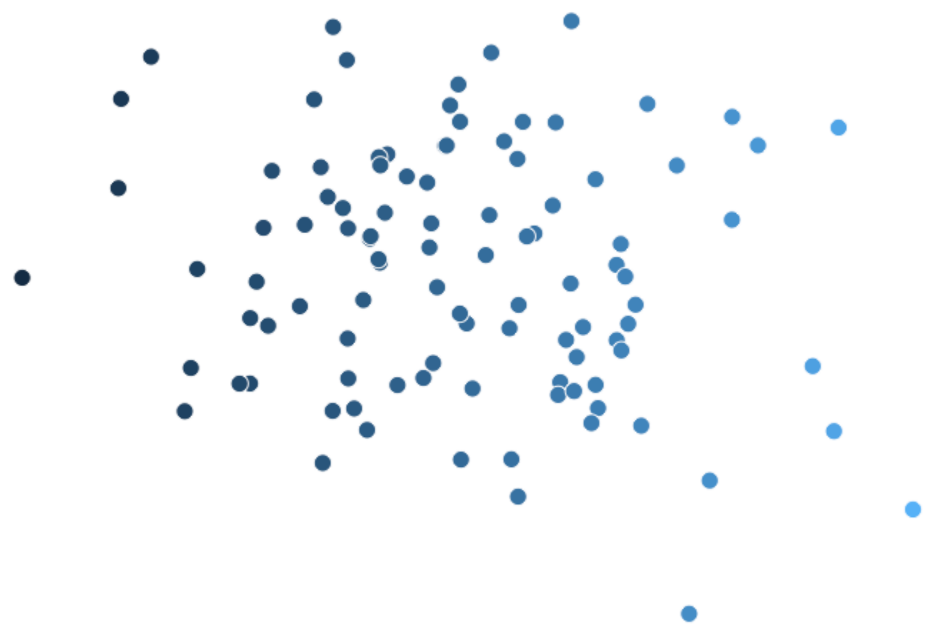
Grammar of Graphics

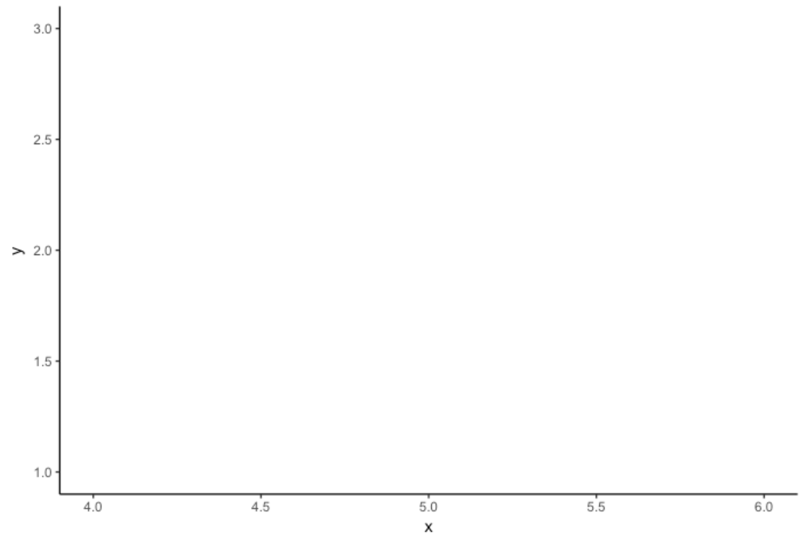
- Leland Wilkinson, *The Grammar of Graphics* (2nd edition, 2005)
- Why focus on grammar?
- More flexible, more room for growth
- ggplot2 is one implementation

Building Blocks

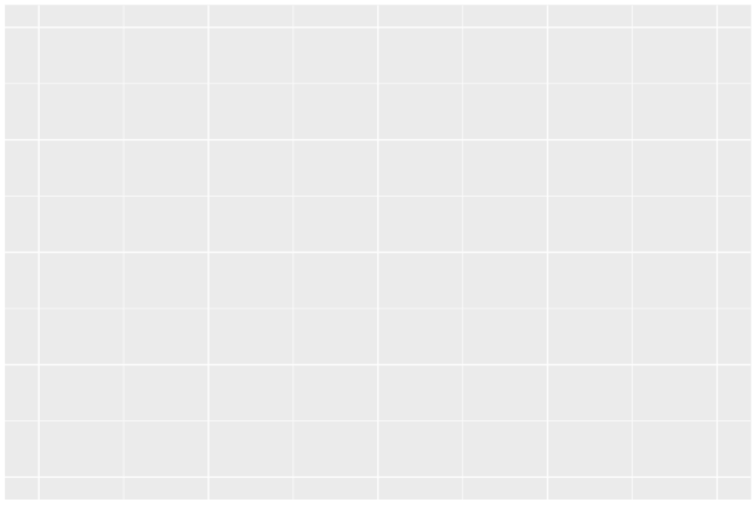
Layer(s)



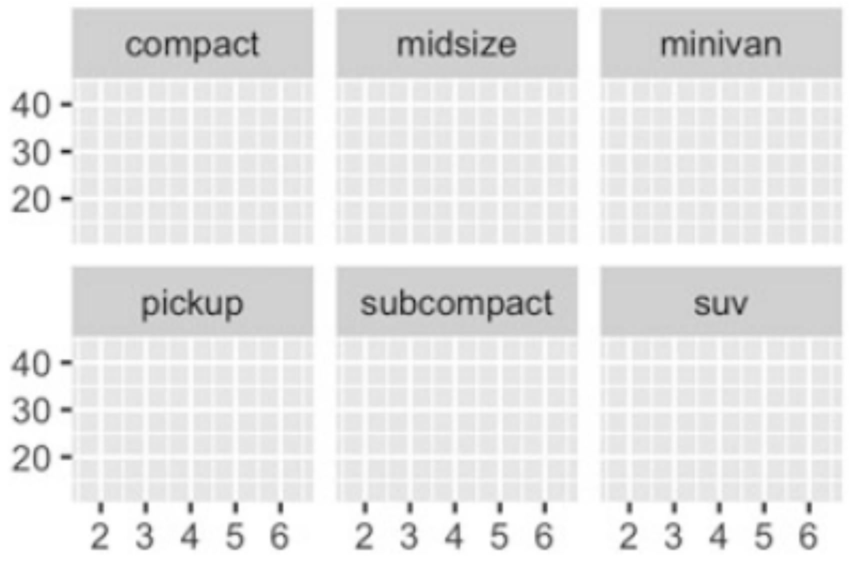
Scale(s)



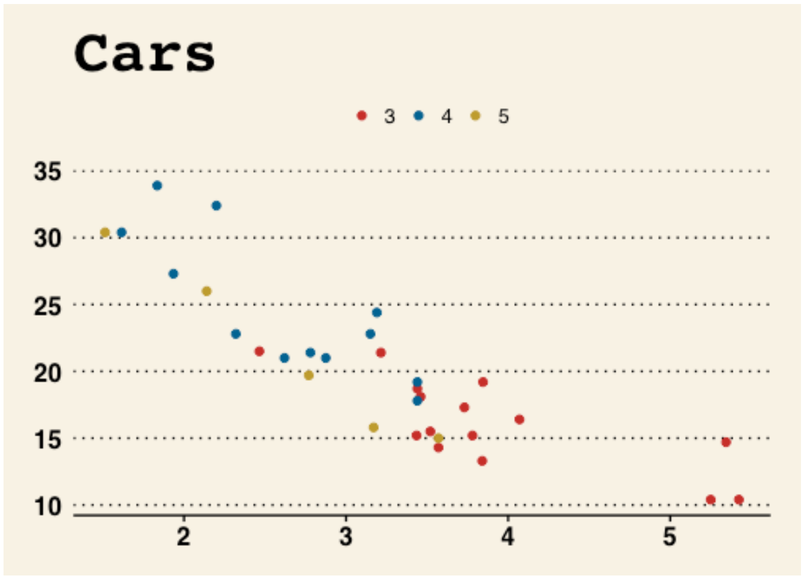
Coord



Facet

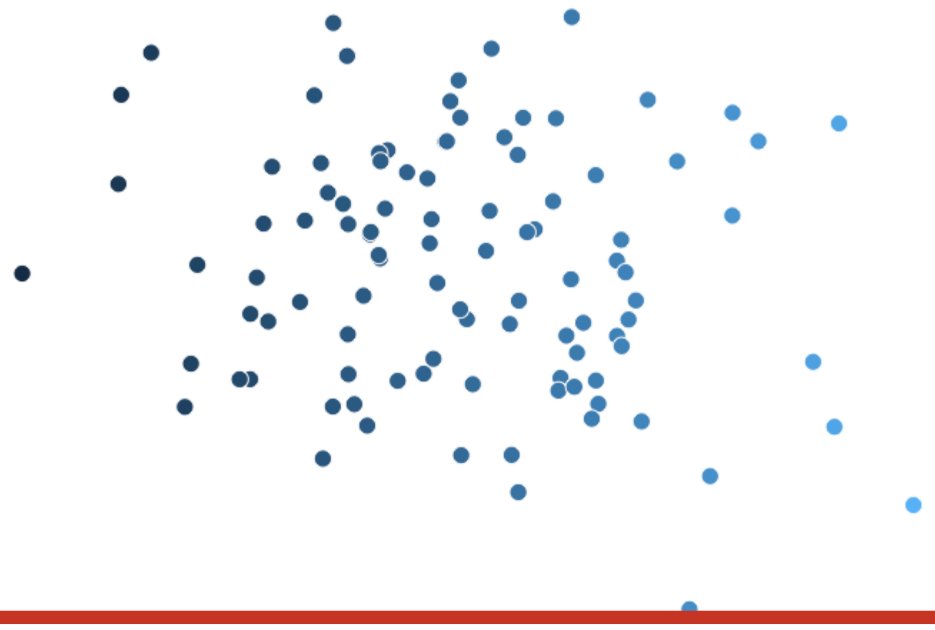


Theme

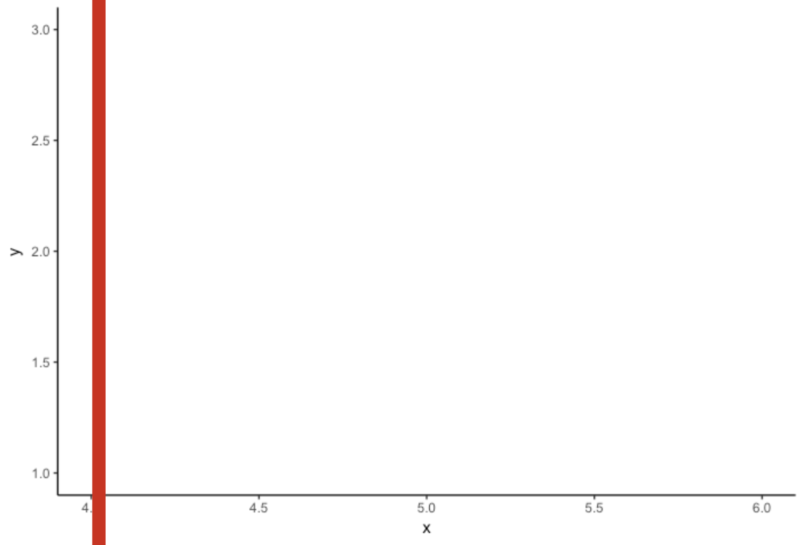


Building Blocks

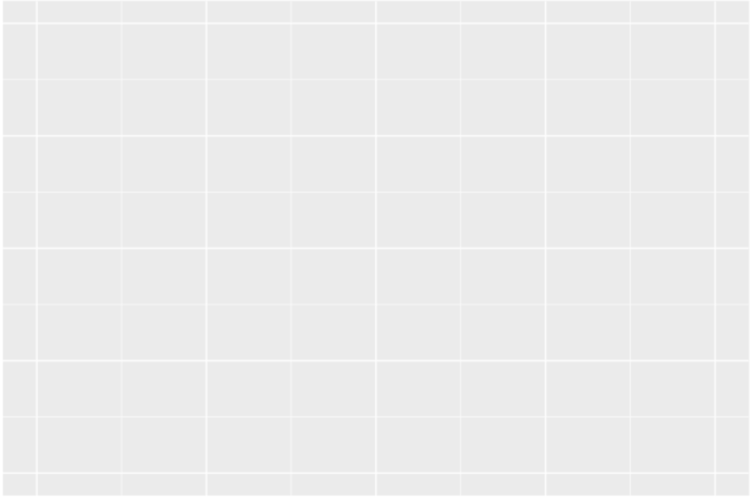
Layer(s)



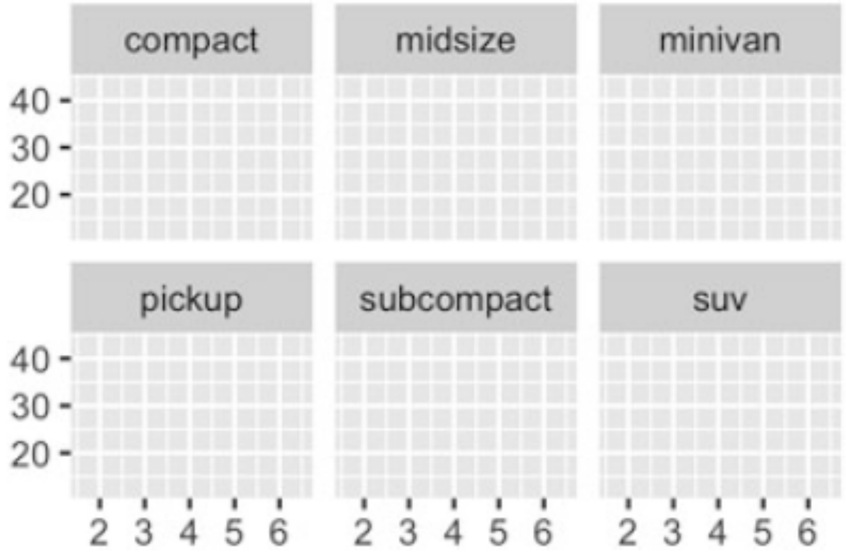
Scale(s)



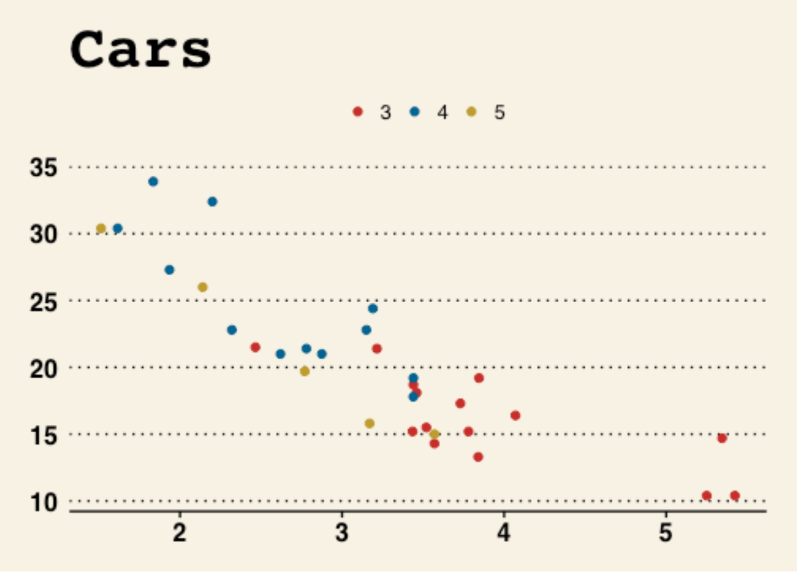
Coord



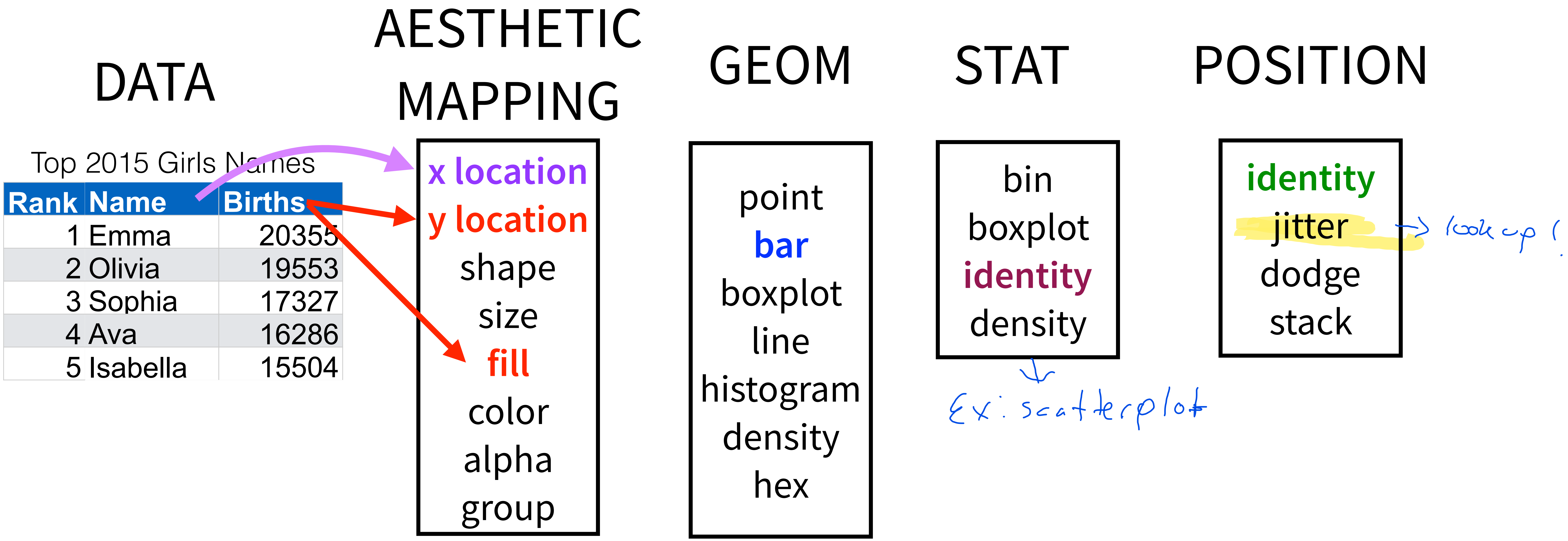
Facet



Theme



Layers



DATA

Top 2015 Girls Names

Rank	Name	Births
1	Emma	20355
2	Olivia	19553
3	Sophia	17327
4	Ava	16286
5	Isabella	15504

AESTHETIC MAPPING

x location
y location
shape
size
fill
color
alpha
group

GEOM

point
bar
boxplot
line
histogram
density
hex

STAT

bin
boxplot
identity
density

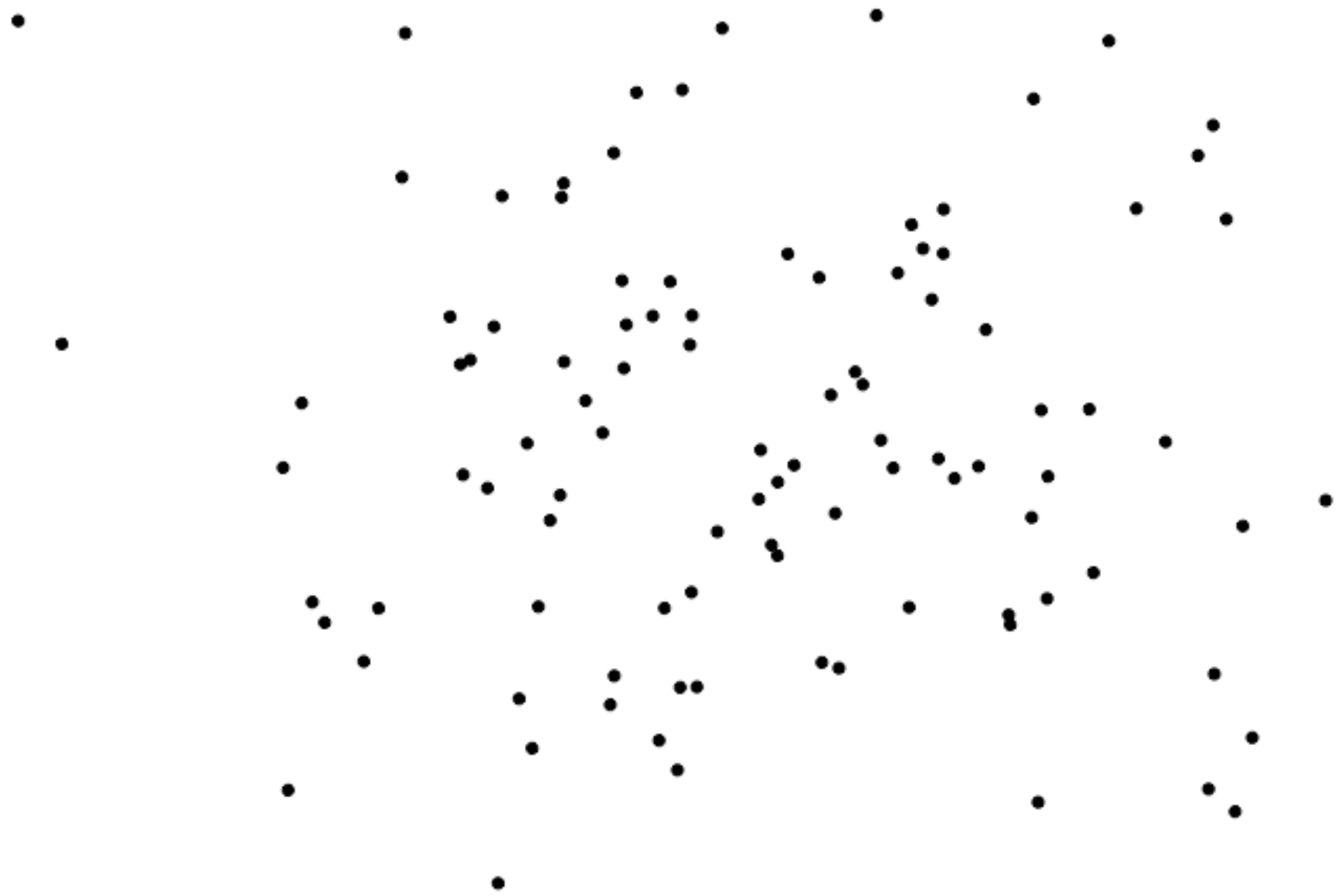
Ex: scatterplot

POSITION

identity
jitter → look up (
dodge
stack

Layer 1

```r
df1 <- data.frame(x = rnorm(100), y = rnorm(100))
```



Data: df1

Mapping: x →x, y →y

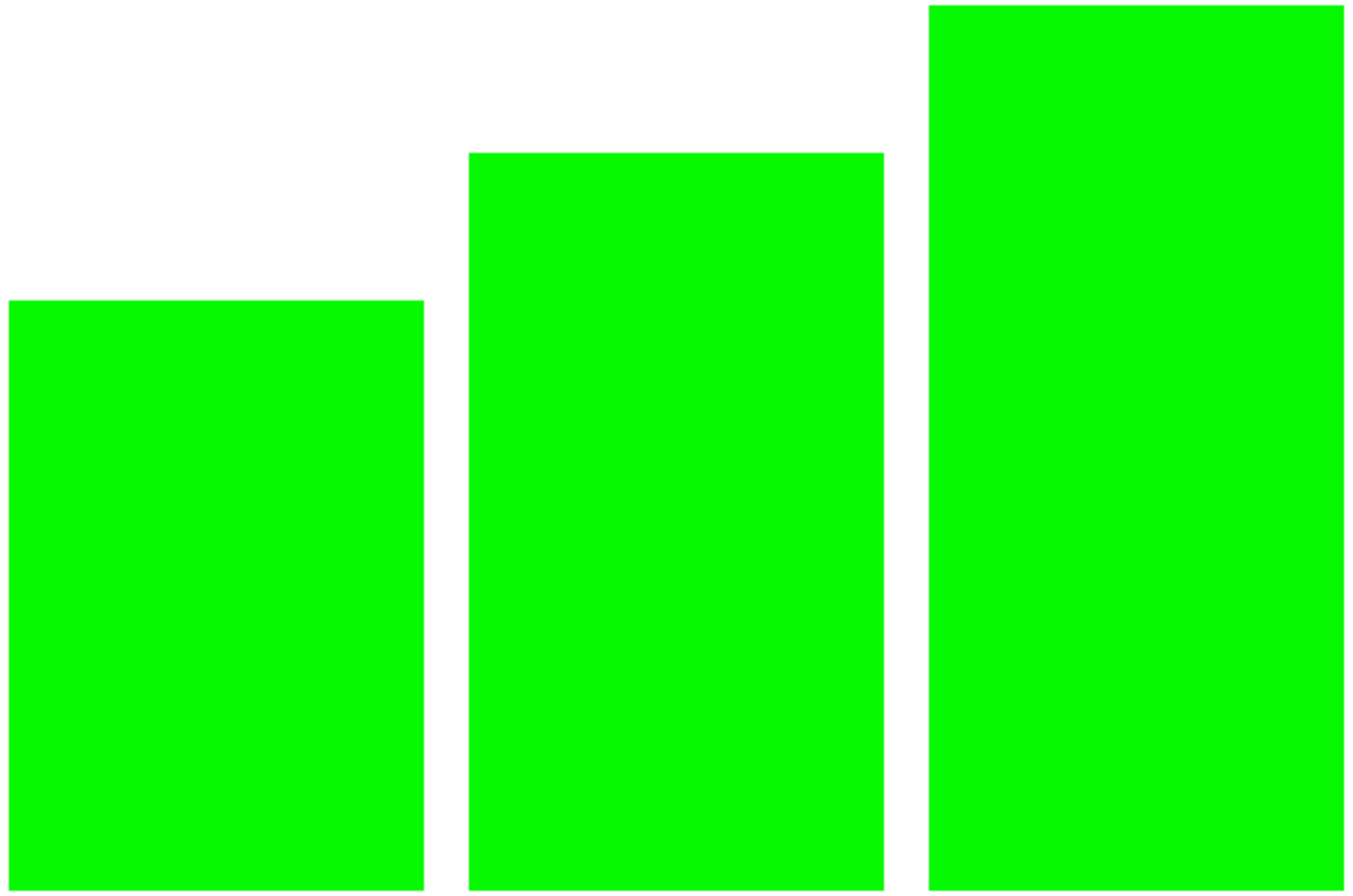
Geom: point

Stat: identity

Position: identity

Layer 2

```
df2 <- data.frame(num = 1:3, height = 4:6)
```



Data: df2

Mapping: num →x,
height →y

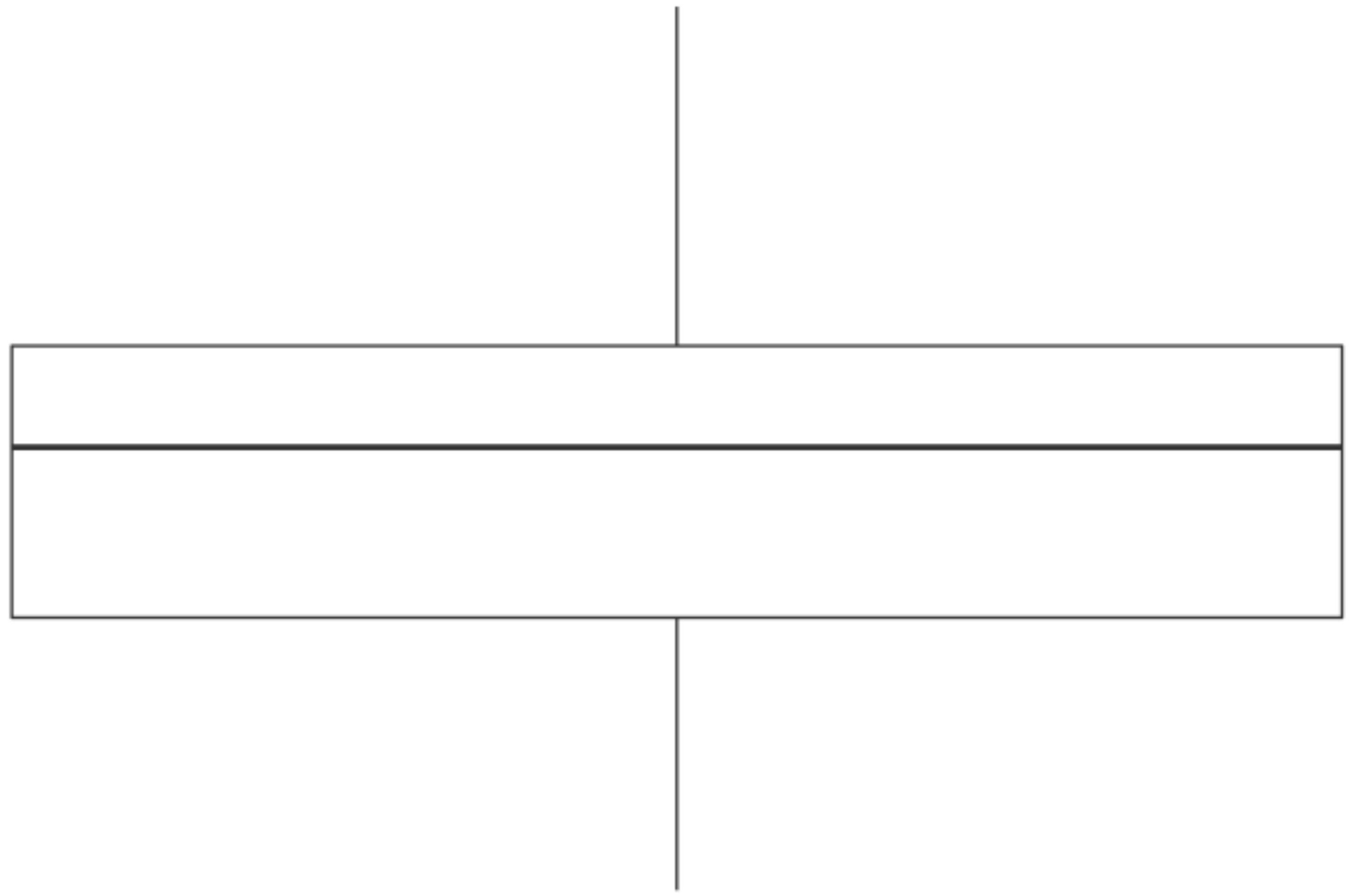
Geom: bar
setting: fill = green

Stat: identity

Position: identity

Layer 3

```
df3 <- data.frame(score = rnorm(25, mean = 15, sd = 3))
```



Data: df3

Mapping: 1 →x,
score →y

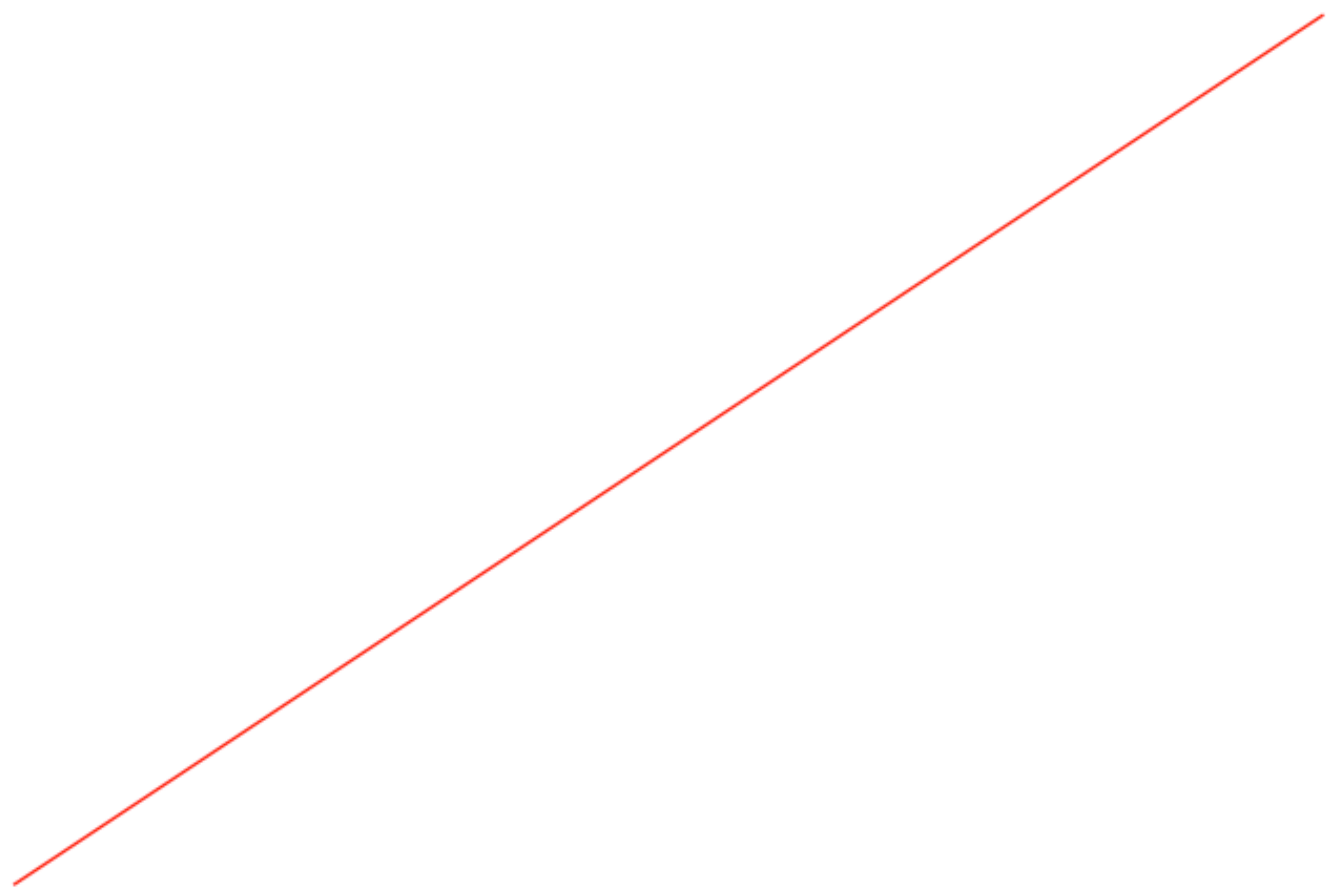
Geom: boxplot

Stat: boxplot

Position: dodge

Layer 4

```r
df4 <- data.frame(time = 1:10, dist = 1:10)
```



Data: df4

Mapping: time→x

dist →y

Geom: line

Stat: identity

Position: identity

Layer 1

```
df1 <- data.frame(x = rnorm(100), y = rnorm(100))
ggplot() + layer(data = df1,
                 mapping = aes(x, y),
                 geom = "point",
                 stat = "identity",
                 position = "identity")
```

(don't actually do this)

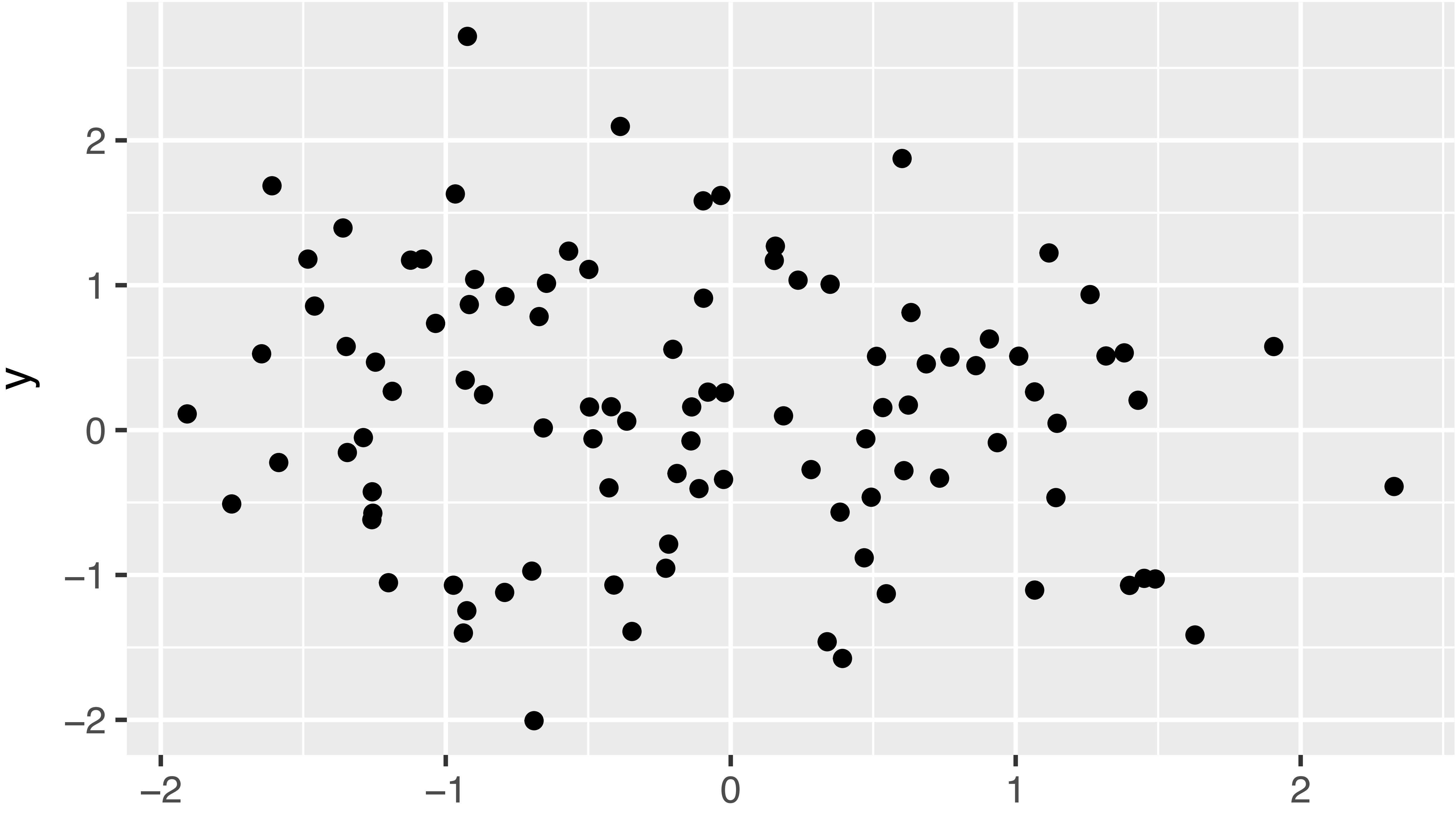
Data: df1

Mapping: x →x, y →y

Geom: point

Stat: identity

Position: identity



Layer 2

```r
df2 <- data.frame(num = 1:3, height = 4:6)
ggplot() +
    layer(data = df2,
          mapping = aes(x = num, y = height),
          geom = "bar", params = list(fill = "green"),
          stat = "identity", position = "identity")
```

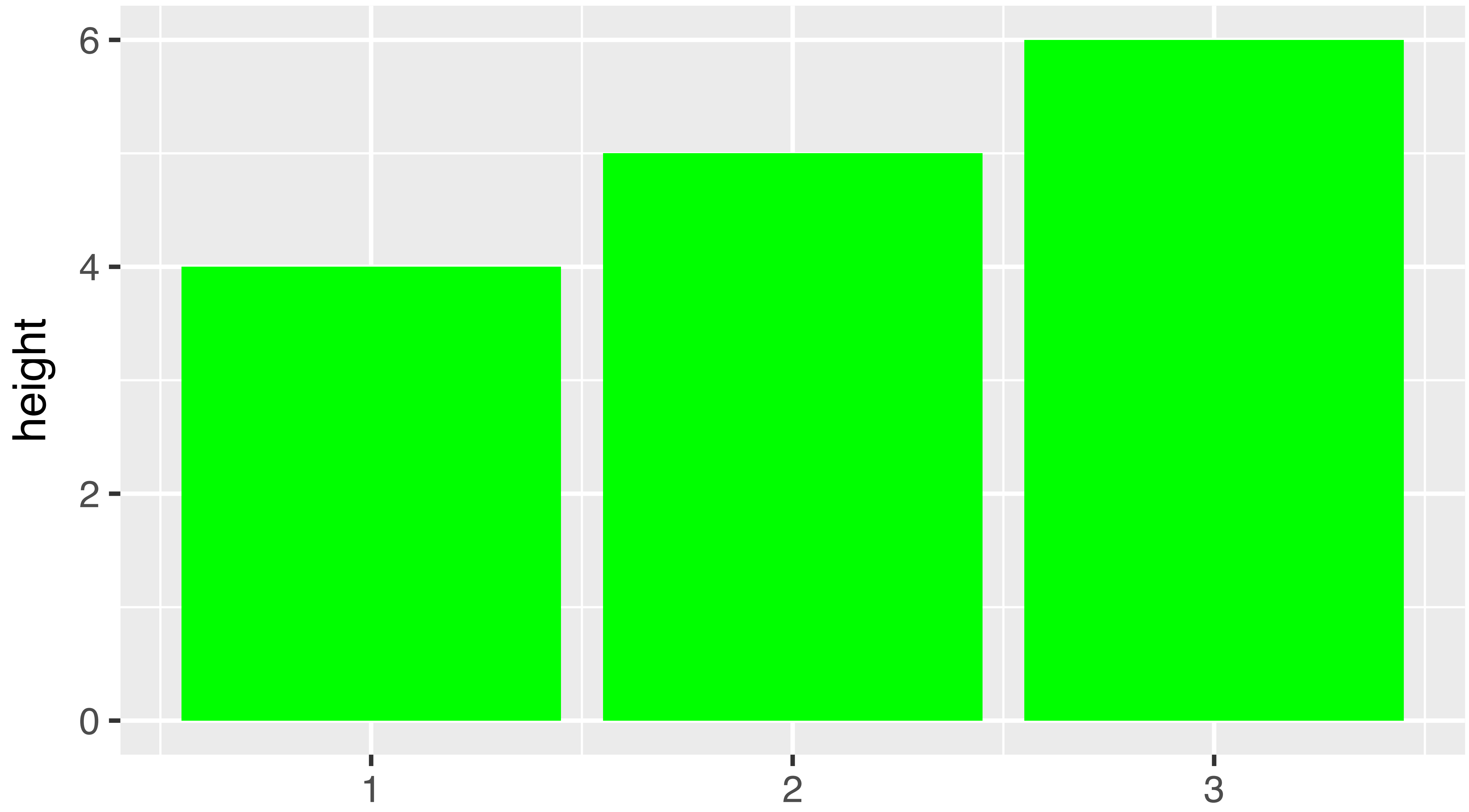
Data: df2

Mapping: num →x,
     height →y

Geom: bar
    setting: fill = green

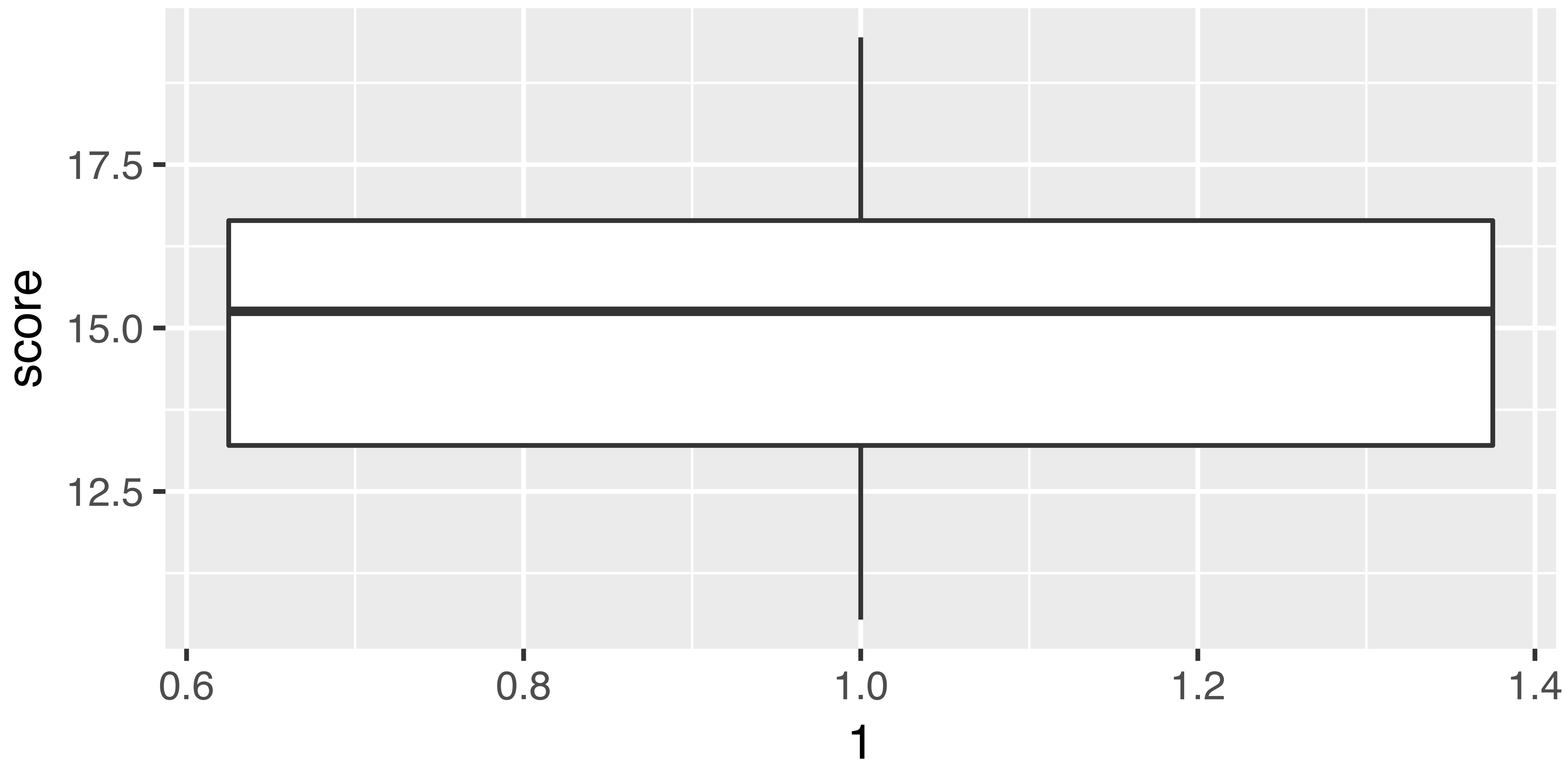
Stat: identity

Position: identity



Layer 3

```r
df3 <- data.frame(score = rnorm(25, mean = 15, sd = 3))
ggplot() + layer(data = df3,
                 mapping = aes(1, score),
                 geom = "boxplot",
                 stat = "boxplot",
                 position = "dodge")
```



Data: df3

Mapping: 1 →x

score →y

Geom: boxplot

Stat: boxplot

Position: dodge

Layer 4

```
df4 <- data.frame(time = 1:10, dist = 1:10)
ggplot() + layer(data = df4,
                 mapping = aes(x = time, y = dist),
                 geom = "line",
                 params = list(color = "red"),
                 stat = "identity", position = "identity")
```

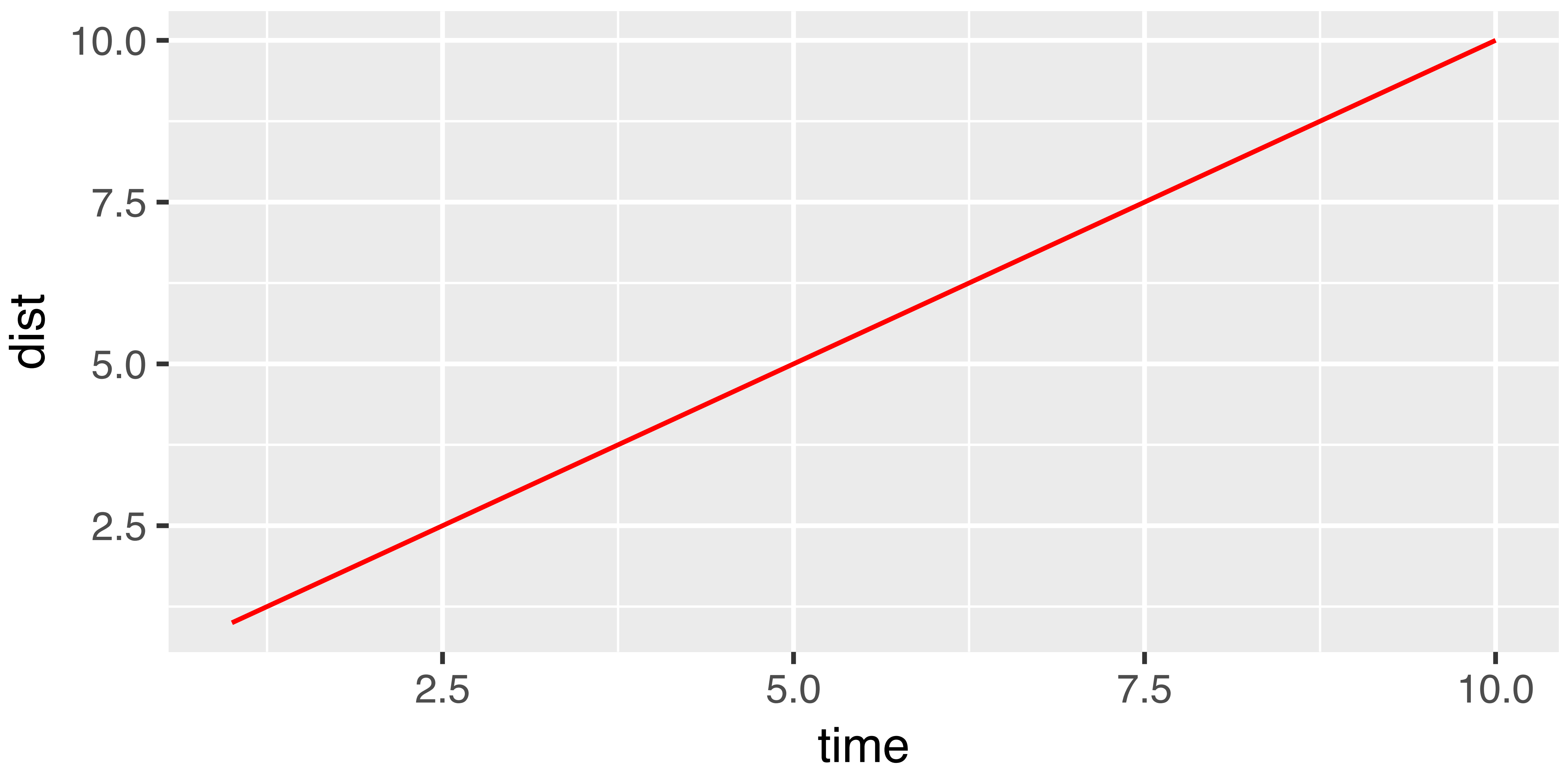
Data: df4

Mapping: time→x
    dist →y

Geom: line

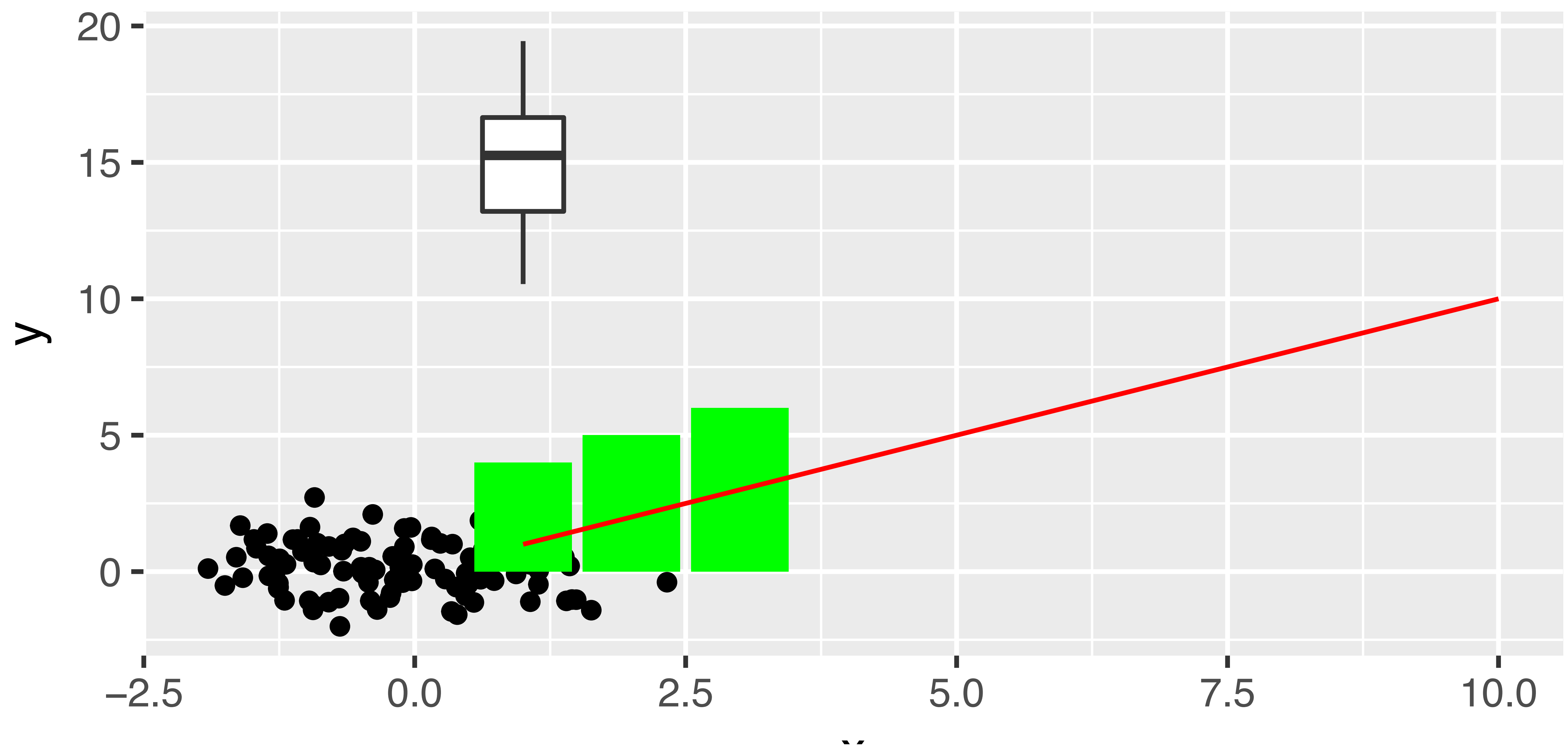
Stat: identity

Position: identity



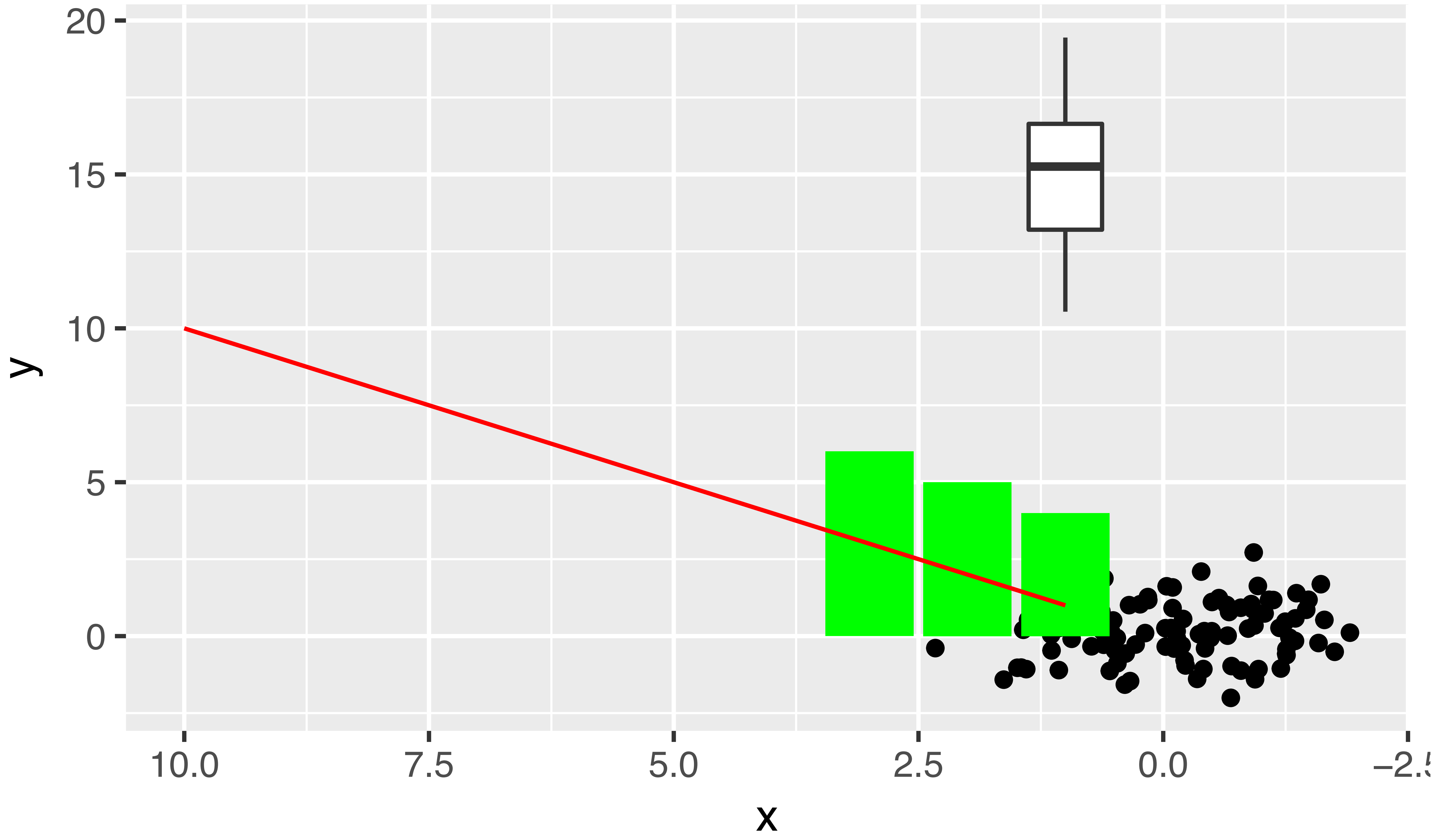
All layers

```r
library (ggplot2)
g <- ggplot() + geom_point(data = df1, aes(x,y)) +
    geom_col(data = df2, aes(num, height),
             fill = "green") +
    geom_boxplot(data = df3, aes(1, score)) +
    geom_line(data = df4, aes(time, dist),
              color = "red")
g
```

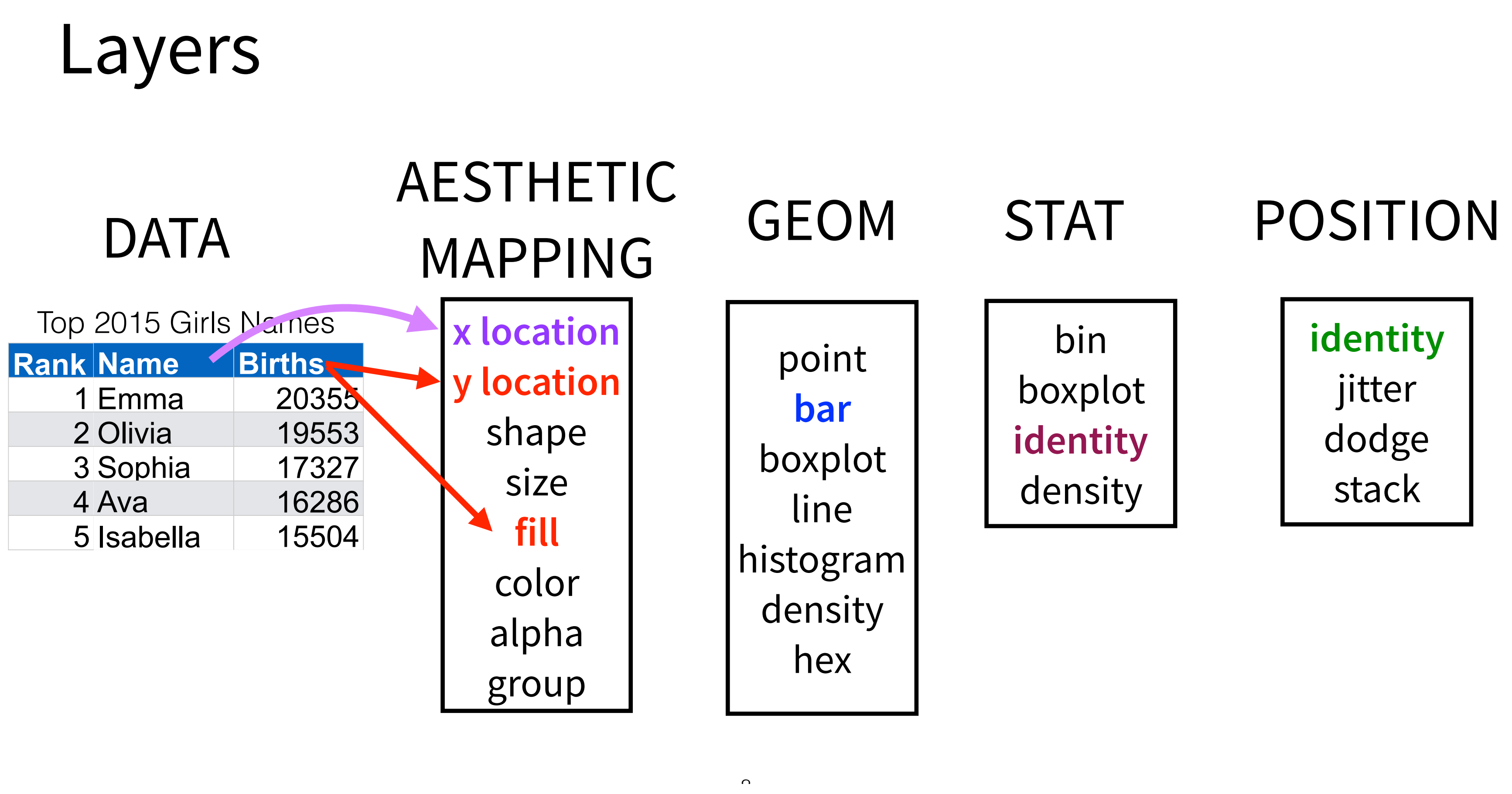


Scale

```
g + scale_x_reverse()
```



One scale per mapping



Layers

DATA

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AESTHETIC MAPPING

x location
y location
shape
size
fill
color
alpha
group

GEOM

point
bar
boxplot
line
histogram
density
hex

STAT

bin
boxplot
identity
density

POSITION

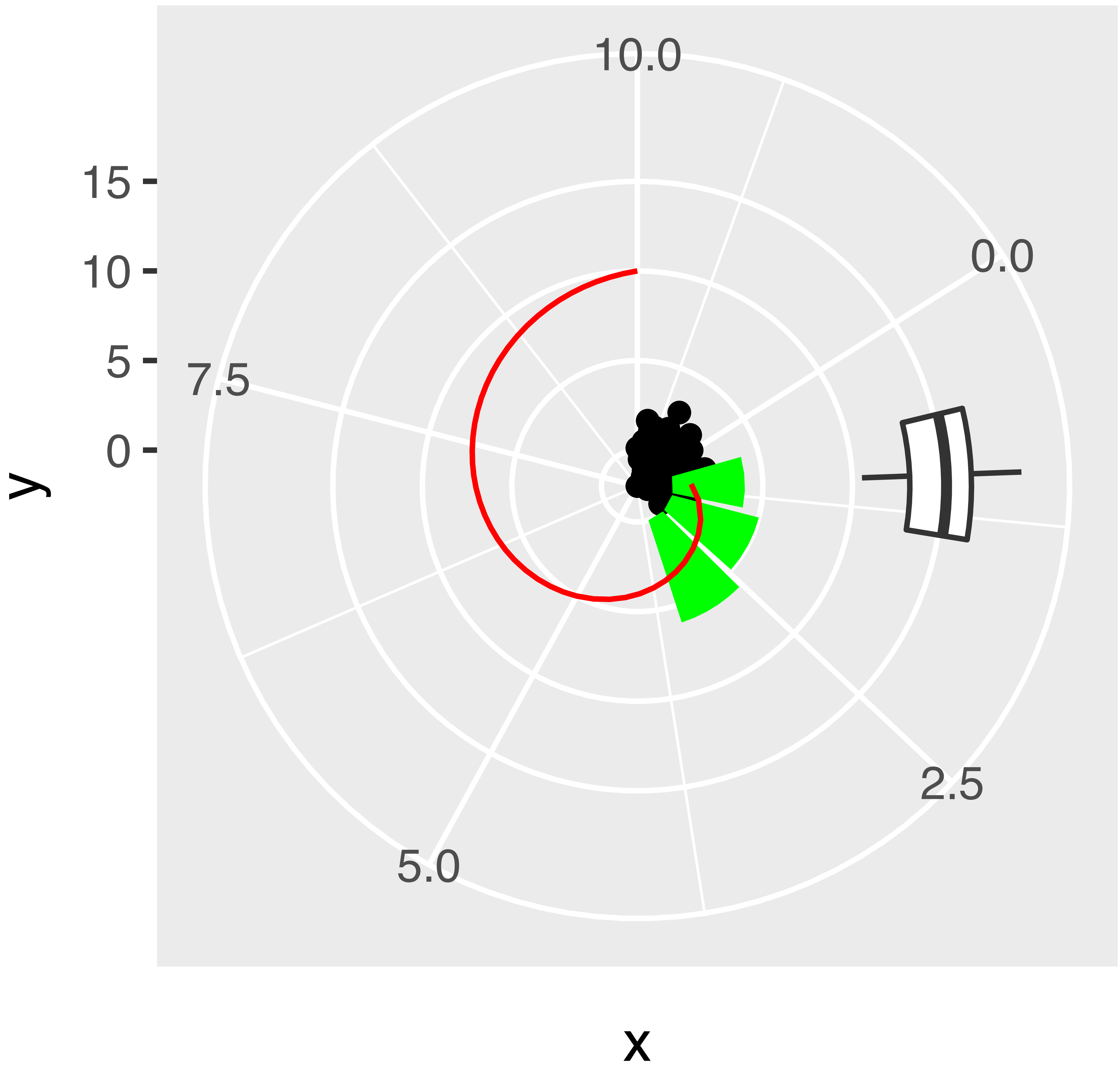
identity
jitter
dodge
stack

MAPPING	SCALE
x →	scale_x_date()
y →	scale_y_continuous()
color →	scale_color_manual()
fill →	scale_fill_viridis_c()

Coord

(only 1!)

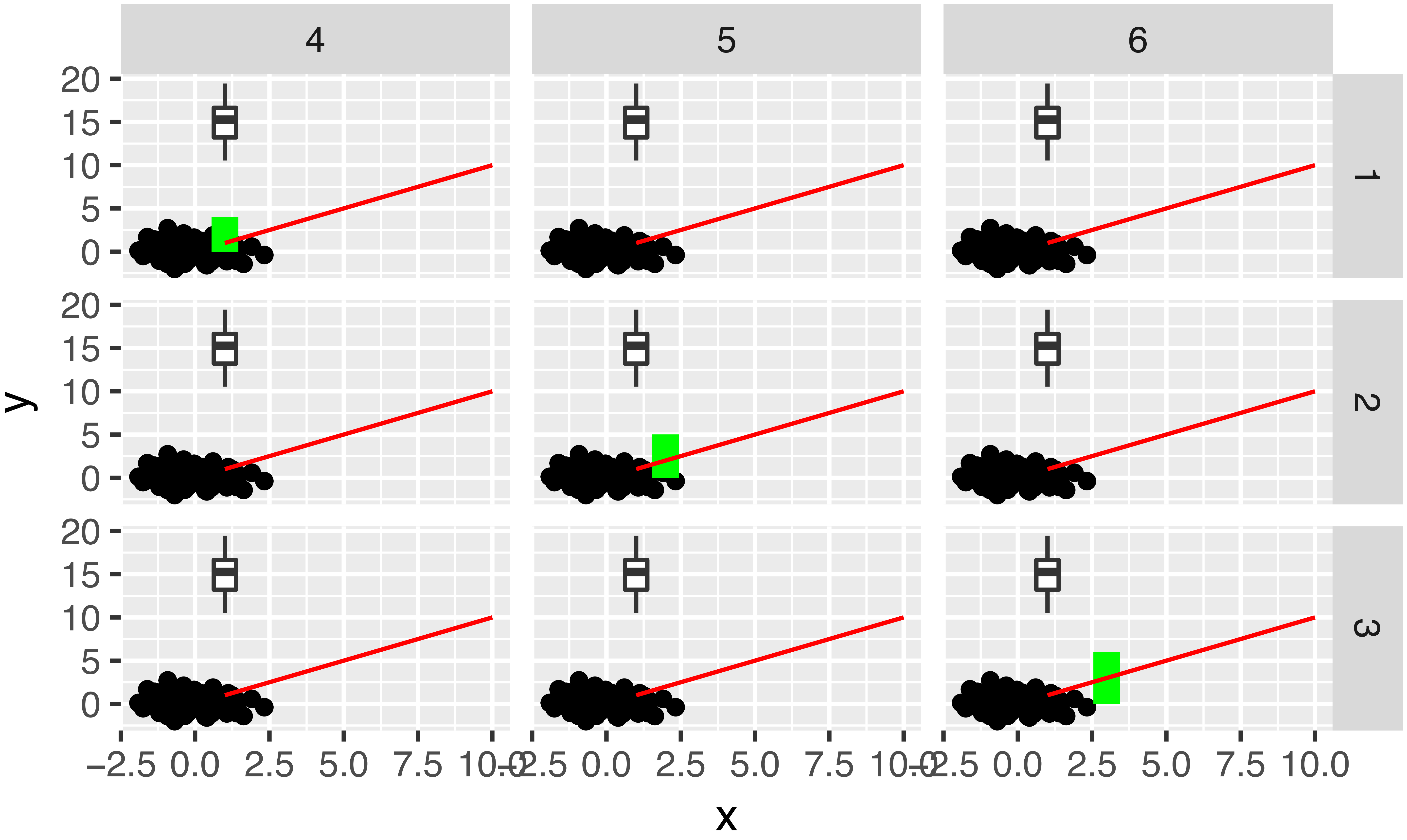
```
g + coord_polar()
```



Facet

(only 1!)

```
g + facet_grid(num~height)
```



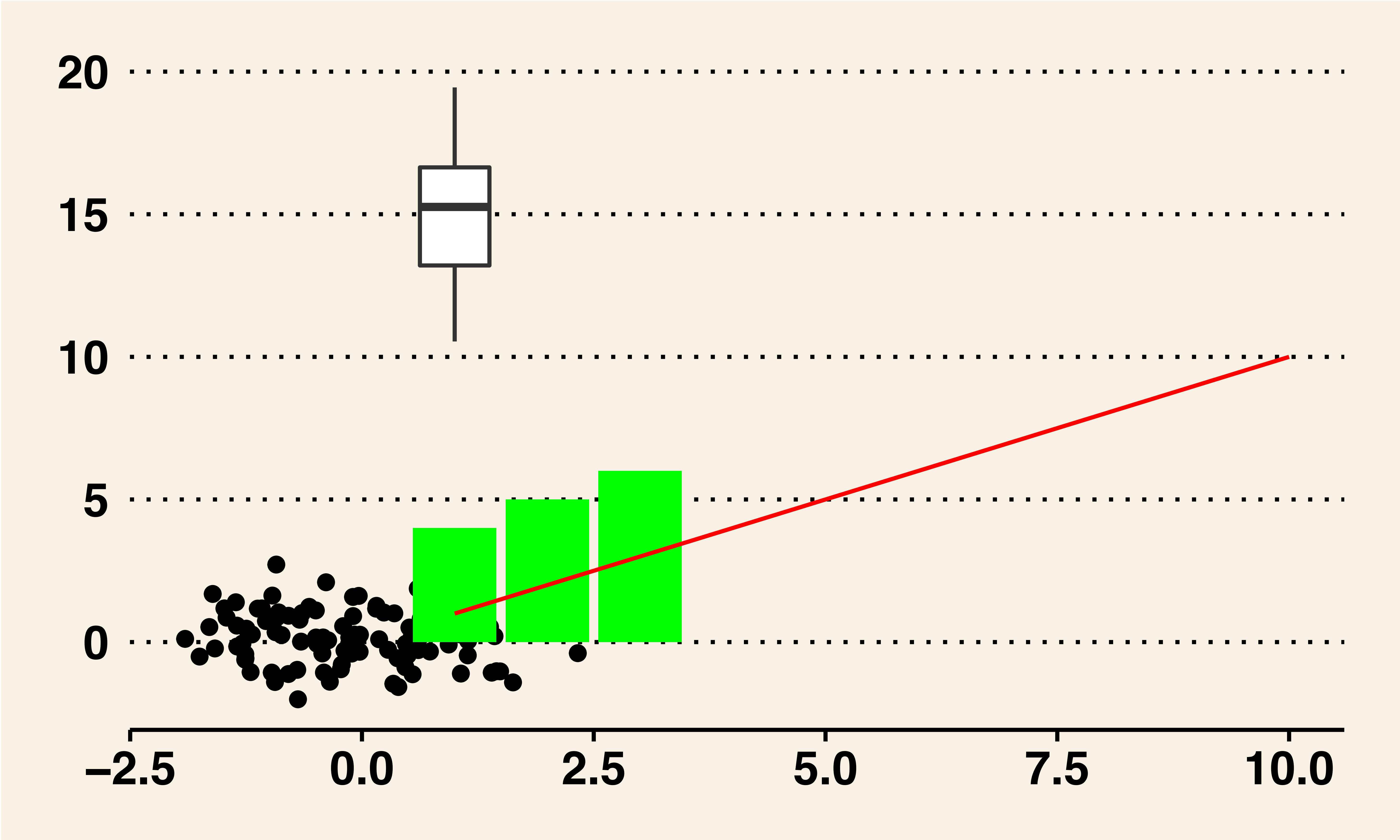
facet_wrap → 1 variable

facet_grid → 2 variable

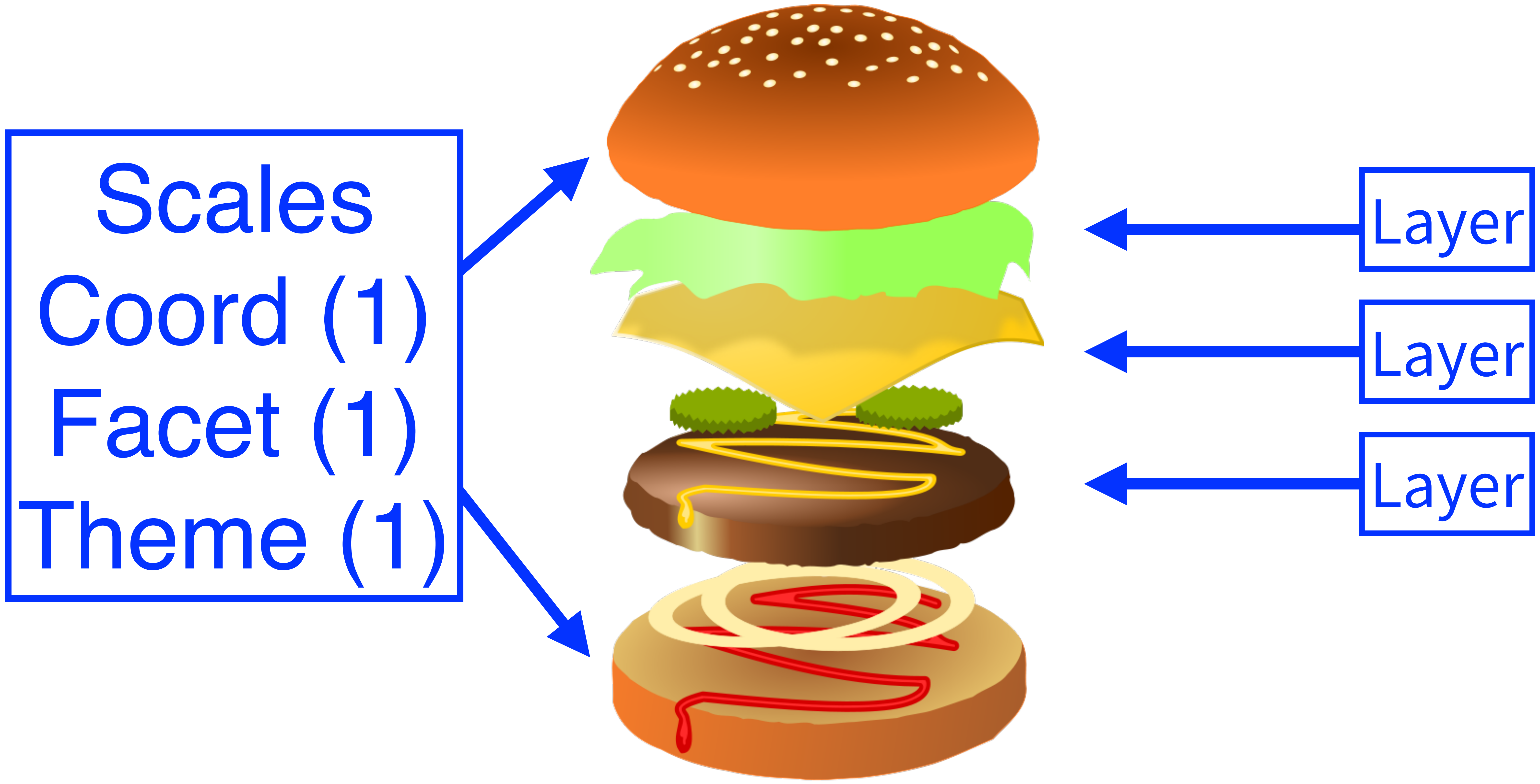
Theme

(only 1!)

```r
library(ggthemes)
g + theme_wsj()
```



Layered Approach



Scales
Coord (1)
Facet (1)
Theme (1)

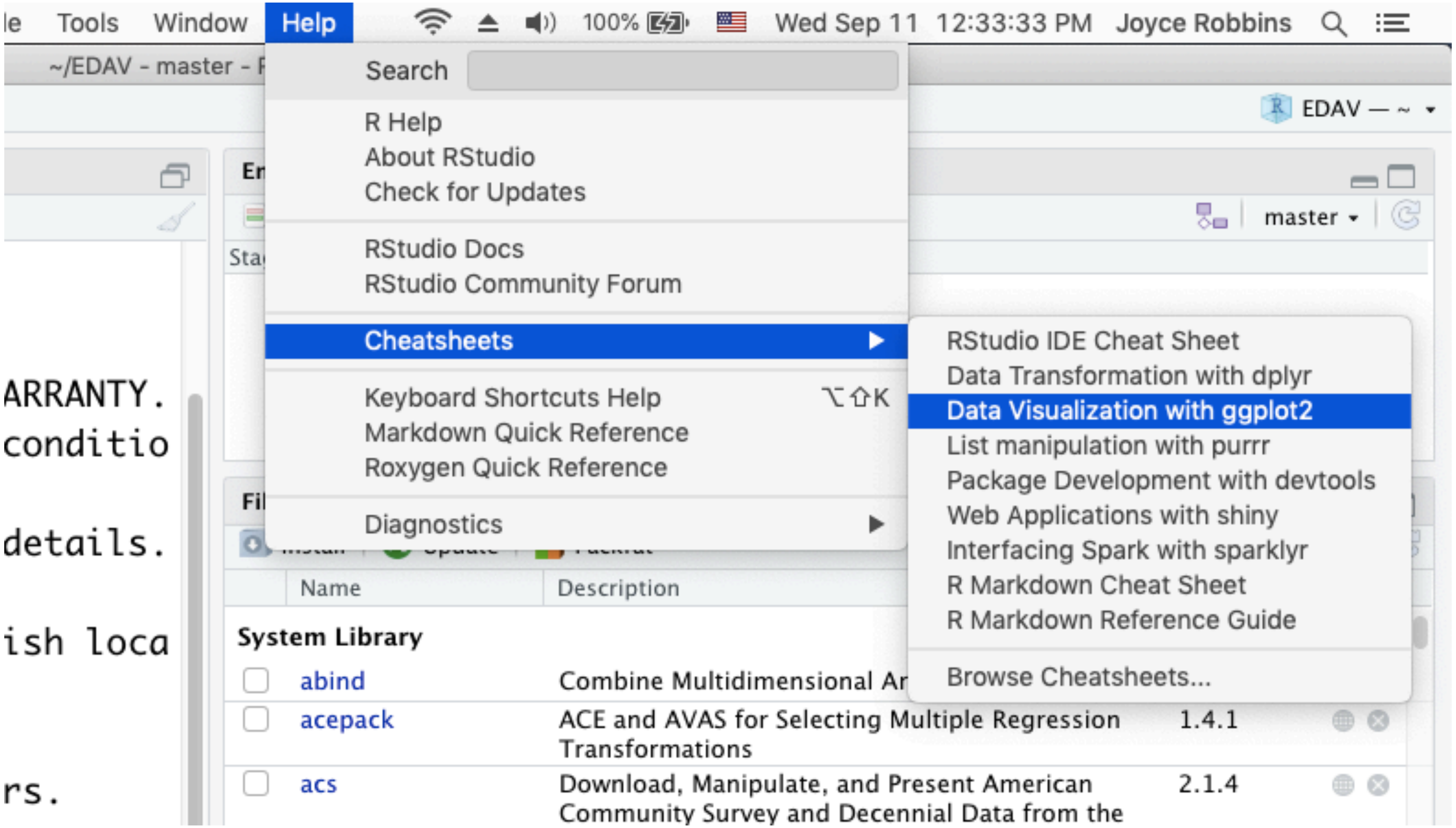
Layer

Layer

Layer

No!

cheatsheet

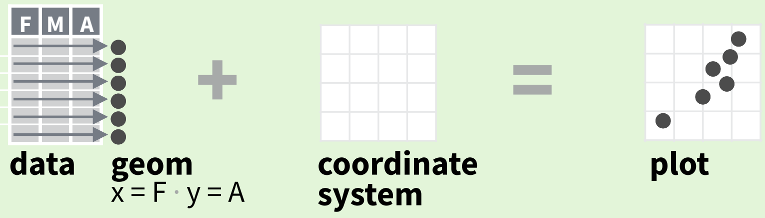


	Name	Description	
	System Library		
□	abind	Combine Multidimensional Ar	
□	acepack	ACE and AVAS for Selecting Multiple Regression Transformations	1.4.1
□	acs	Download, Manipulate, and Present American Community Survey and Decennial Data from the	2.1.4

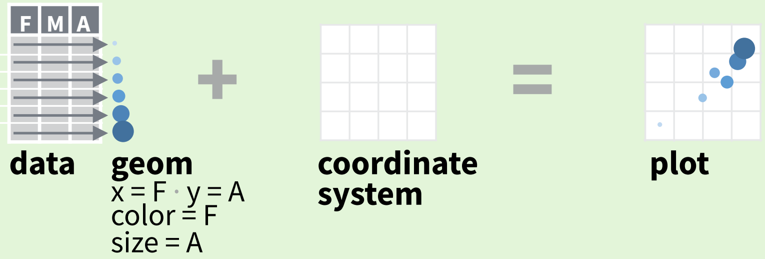
Data Visualization with ggplot2 : : CHEAT SHEET

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.


F M A
+
=
data **geom** x = F · y = A **coordinate system** **plot**

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


F M A
+
=
data **geom** x = F · y = A color = F size = A **coordinate system** **plot**

Complete the template below to build a graph.

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

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”**)** Creates a complete plot with given data, geom, and mappings. Supplies many useful defaults.~~

last_plot() Returns the last plot

~~**ggsave("plot.png", width = 5, height = 5)** Saves last plot as 5’ x 5’ file named "plot.png" in working directory. Matches file type to file extension.~~

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

c + geom_freqpoly() x, y, alpha, color, group, linetype, size

c + geom_histogram(binwidth = 5**)** x, y, alpha, color, fill, linetype, size, weight

c2 + geom_qq(aes(sample = hwy)**)** x, y, alpha, color, fill, linetype, size, weight

discrete

d <- ggplot(mpg, aes(fl))

d + geom_bar()
x, alpha, color, fill, linetype, size, weight

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

discrete x , discrete y

g <- ggplot(diamonds, aes(cut, color))

g + geom_count(), x, y, alpha, color, fill, shape, size, stroke

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,
state = tolower(rownames(USArrests)))
map <- map_data("state")
k <- ggplot(data, aes(fill = murder))

k + geom_map(aes(map_id = state), map = map)
+ expand_limits(x = map$long, y = map$lat**)**,
map_id, alpha, color, fill, linetype, size

THREE VARIABLES

seals$z <- with(seals, sqrt(delta_long^2 + delta_lat^2)); l <- ggplot(seals, aes(long, lat))

l + geom_contour(aes(z = z))
x, y, z, alpha, colour, group, linetype, size, weight

l + geom_raster(aes(fill = z), hjust=0.5, vjust=0.5, interpolate=FALSE**)**
x, y, alpha, fill

l + geom_tile(aes(fill = z)), x, y, alpha, color, fill, linetype, size, width

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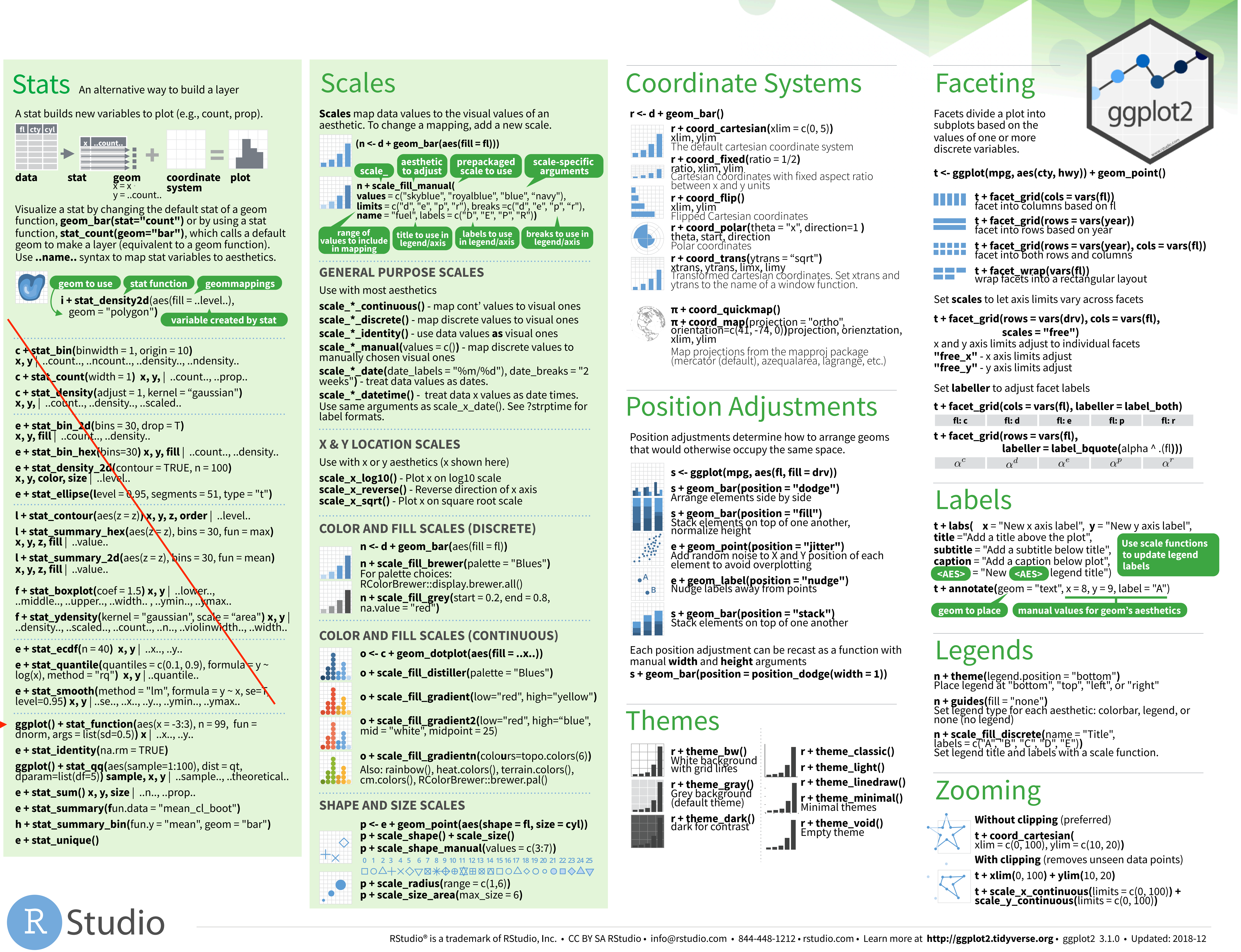


Stats

An alternative way to build a layer

A stat builds new variables to plot (e.g., count, prop).

fl | cty | cyl
x | ..count..
data
stat
geom
x = x
y = ..count..
coordinate system
plot

Visualize a stat by changing the default stat of a geom function, **geom_bar(stat="count")** or by using a stat function, **stat_count(geom="bar")**, which calls a default geom to make a layer (equivalent to a geom function). Use **..name..** syntax to map stat variables to aesthetics.

geom to use · stat function · geommappings

i + stat_density2d(aes(fill = ..level..), geom = "polygon")

variable created by stat

c + stat_bin(binwidth = 1, origin = 10**)**
x, y | ..count.., ..ncount.., ..density.., ..ndensity..

c + stat_count(width = 1**) x, y,** | ..count.., ..prop..

c + stat_density(adjust = 1, kernel = “gaussian"**)**
x, y, | ..count.., ..density.., ..scaled..

e + stat_bin_2d(bins = 30, drop = T**)**
x, y, fill | ..count.., ..density..

e + stat_bin_hex(bins=30**) x, y, fill** | ..count.., ..density..

e + stat_density_2d(contour = TRUE, n = 100**)**
x, y, color, size | ..level..

e + stat_ellipse(level = 0.95, segments = 51, type = "t"**)**

l + stat_contour(aes(z = z)**) x, y, z, order** | ..level..

l + stat_summary_hex(aes(z = z), bins = 30, fun = max**)**
x, y, z, fill | ..value..

l + stat_summary_2d(aes(z = z), bins = 30, fun = mean**)**
x, y, z, fill | ..value..

f + stat_boxplot(coef = 1.5**) x, y** | ..lower.., ..middle.., ..upper.., ..width.. , ..ymin.., ..ymax..

f + stat_ydensity(kernel = "gaussian", scale = “area"**) x, y** | ..density.., ..scaled.., ..count.., ..n.., ..violinwidth.., ..width..

e + stat_ecdf(n = 40**) x, y** | ..x.., ..y..

e + stat_quantile(quantiles = c(0.1, 0.9), formula = y ~ log(x), method = "rq"**) x, y** | ..quantile..

e + stat_smooth(method = "lm", formula = y ~ x, se=T, level=0.95**) x, y** | ..se.., ..x.., ..y.., ..ymin.., ..ymax..

ggplot() + stat_function(aes(x = -3:3), n = 99, fun = dnorm, args = list(sd=0.5)**) x** | ..x.., ..y..

e + stat_identity(na.rm = TRUE**)**

ggplot() + stat_qq(aes(sample=1:100), dist = qt, dparam=list(df=5)**) sample, x, y** | ..sample.., ..theoretical..

e + stat_sum() x, y, size | ..n.., ..prop..

e + stat_summary(fun.data = "mean_cl_boot"**)**

h + stat_summary_bin(fun.y = "mean", geom = "bar"**)**

e + stat_unique()

Scales

Scales map data values to the visual values of an aesthetic. To change a mapping, add a new scale.

(n <- d + geom_bar(aes(fill = fl)))

scale_ · aesthetic to adjust · prepackaged scale to use · scale-specific arguments

n + scale_fill_manual(
values = c("skyblue", "royalblue", "blue", “navy"),
limits = c("d", "e", "p", "r"), breaks =c("d", "e", "p", “r"),
name = "fuel", labels = c("D", "E", "P", "R")**)**

range of values to include in mapping · title to use in legend/axis · labels to use in legend/axis · breaks to use in legend/axis

GENERAL PURPOSE SCALES

Use with most aesthetics

scale_*_continuous() - map cont’ values to visual ones
scale_*_discrete() - map discrete values to visual ones
scale_*_identity() - use data values **as** visual ones
scale_*_manual(values = c()**)** - map discrete values to manually chosen visual ones
scale_*_date(date_labels = "%m/%d"), date_breaks = "2 weeks"**)** - treat data values as dates.
scale_*_datetime() - treat data x values as date times. Use same arguments as scale_x_date(). See ?strptime for label formats.

X & Y LOCATION SCALES

Use with x or y aesthetics (x shown here)

scale_x_log10() - Plot x on log10 scale
scale_x_reverse() - Reverse direction of x axis
scale_x_sqrt() - Plot x on square root scale

COLOR AND FILL SCALES (DISCRETE)

n <- d + geom_bar(aes(fill = fl)**)**

n + scale_fill_brewer(palette = "Blues"**)**
For palette choices:
RColorBrewer::display.brewer.all()

n + scale_fill_grey(start = 0.2, end = 0.8, na.value = "red"**)**

COLOR AND FILL SCALES (CONTINUOUS)

o <- c + geom_dotplot(aes(fill = ..x..))

o + scale_fill_distiller(palette = "Blues"**)**

o + scale_fill_gradient(low="red", high="yellow"**)**

o + scale_fill_gradient2(low="red", high=“blue", mid = "white", midpoint = 25**)**

o + scale_fill_gradientn(colours=topo.colors(6)**)**
Also: rainbow(), heat.colors(), terrain.colors(), cm.colors(), RColorBrewer::brewer.pal()

SHAPE AND SIZE SCALES

p <- e + geom_point(aes(shape = fl, size = cyl))
p + scale_shape() + scale_size()
p + scale_shape_manual(values = c(3:7)**)**

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
□ ○ △ + × ◇ ▽ ⊠ ✳ ◈ ⊕ ✡ ⊞ ⊠ ◪ ■ ● ▲ ◆ ● • ○ □ ◇ △ ▽

p + scale_radius(range = c(1,6)**)**
p + scale_size_area(max_size = 6**)**

Coordinate Systems

r <- d + geom_bar()

r + coord_cartesian(xlim = c(0, 5)**)**
xlim, ylim
The default cartesian coordinate system

r + coord_fixed(ratio = 1/2**)**
ratio, xlim, ylim
Cartesian coordinates with fixed aspect ratio between x and y units

r + coord_flip()
xlim, ylim
Flipped Cartesian coordinates

r + coord_polar(theta = "x", direction=1 **)**
theta, start, direction
Polar coordinates

r + coord_trans(ytrans = “sqrt"**)**
xtrans, ytrans, limx, limy
Transformed cartesian coordinates. Set xtrans and ytrans to the name of a window function.

π + coord_quickmap()
π + coord_map(projection = "ortho", orientation=c(41, -74, 0)**)**projection, orienztation, xlim, ylim
Map projections from the mapproj package (mercator (default), azequalarea, lagrange, etc.)

Position Adjustments

Position adjustments determine how to arrange geoms that would otherwise occupy the same space.

s <- ggplot(mpg, aes(fl, fill = drv))

s + geom_bar(position = "dodge")
Arrange elements side by side

s + geom_bar(position = "fill")
Stack elements on top of one another, normalize height

e + geom_point(position = "jitter")
Add random noise to X and Y position of each element to avoid overplotting

e + geom_label(position = "nudge")
Nudge labels away from points

s + geom_bar(position = "stack")
Stack elements on top of one another

Each position adjustment can be recast as a function with manual **width** and **height** arguments
s + geom_bar(position = position_dodge(width = 1))

Themes

r + theme_bw()
White background with grid lines

r + theme_gray()
Grey background (default theme)

r + theme_dark()
dark for contrast

r + theme_classic()

r + theme_light()

r + theme_linedraw()

r + theme_minimal()
Minimal themes

r + theme_void()
Empty theme

Faceting

Facets divide a plot into subplots based on the values of one or more discrete variables.

t <- ggplot(mpg, aes(cty, hwy)) + geom_point()

t + facet_grid(cols = vars(fl))
facet into columns based on fl

t + facet_grid(rows = vars(year))
facet into rows based on year

t + facet_grid(rows = vars(year), cols = vars(fl))
facet into both rows and columns

t + facet_wrap(vars(fl))
wrap facets into a rectangular layout

Set **scales** to let axis limits vary across facets

t + facet_grid(rows = vars(drv), cols = vars(fl),
scales = "free")
x and y axis limits adjust to individual facets
"free_x" - x axis limits adjust
"free_y" - y axis limits adjust

Set **labeller** to adjust facet labels

t + facet_grid(cols = vars(fl), labeller = label_both)

fl: c · fl: d · fl: e · fl: p · fl: r

t + facet_grid(rows = vars(fl),
labeller = label_bquote(alpha ^ .(fl)**))**

α^c · α^d · α^e · α^p · α^r

Labels

t + labs(**x** = "New x axis label", **y** = "New y axis label",
title ="Add a title above the plot",
subtitle = "Add a subtitle below title",
caption = "Add a caption below plot",
<AES> = "New <AES> legend title")

Use scale functions to update legend labels

t + annotate(geom = "text", x = 8, y = 9, label = "A")

geom to place · manual values for geom’s aesthetics

Legends

n + theme(legend.position = "bottom"**)**
Place legend at "bottom", "top", "left", or "right"

n + guides(fill = "none"**)**
Set legend type for each aesthetic: colorbar, legend, or none (no legend)

n + scale_fill_discrete(name = "Title", labels = c("A", "B", "C", "D", "E")**)**
Set legend title and labels with a scale function.

Zooming

Without clipping (preferred)

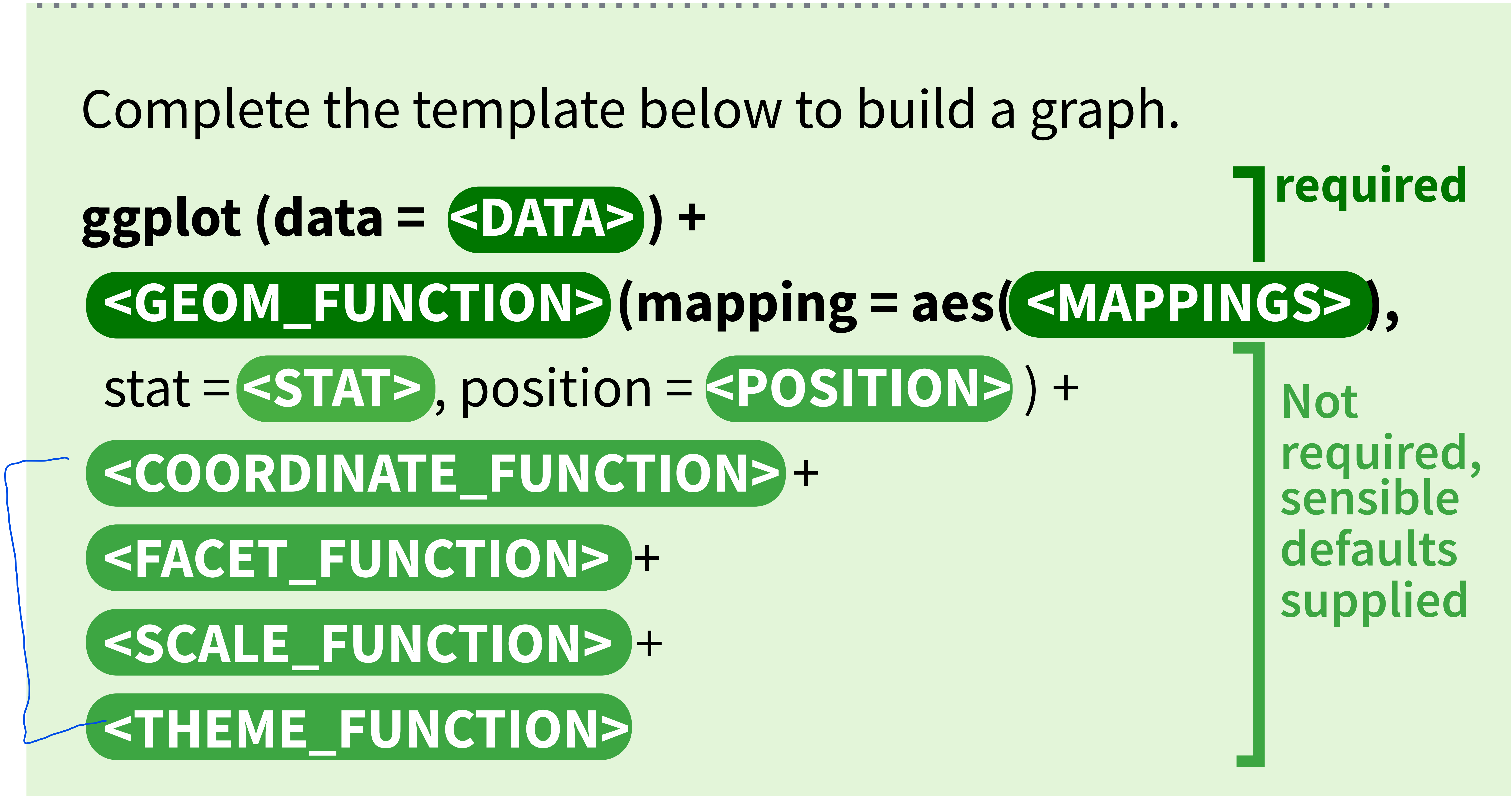
t + coord_cartesian(
xlim = c(0, 100), ylim = c(10, 20)**)**

With clipping (removes unseen data points)

t + xlim(0, 100**) + ylim(**10, 20**)**

t + scale_x_continuous(limits = c(0, 100)**) +**
scale_y_continuous(limits = c(0, 100)**)**

code style



Complete the template below to build a graph.

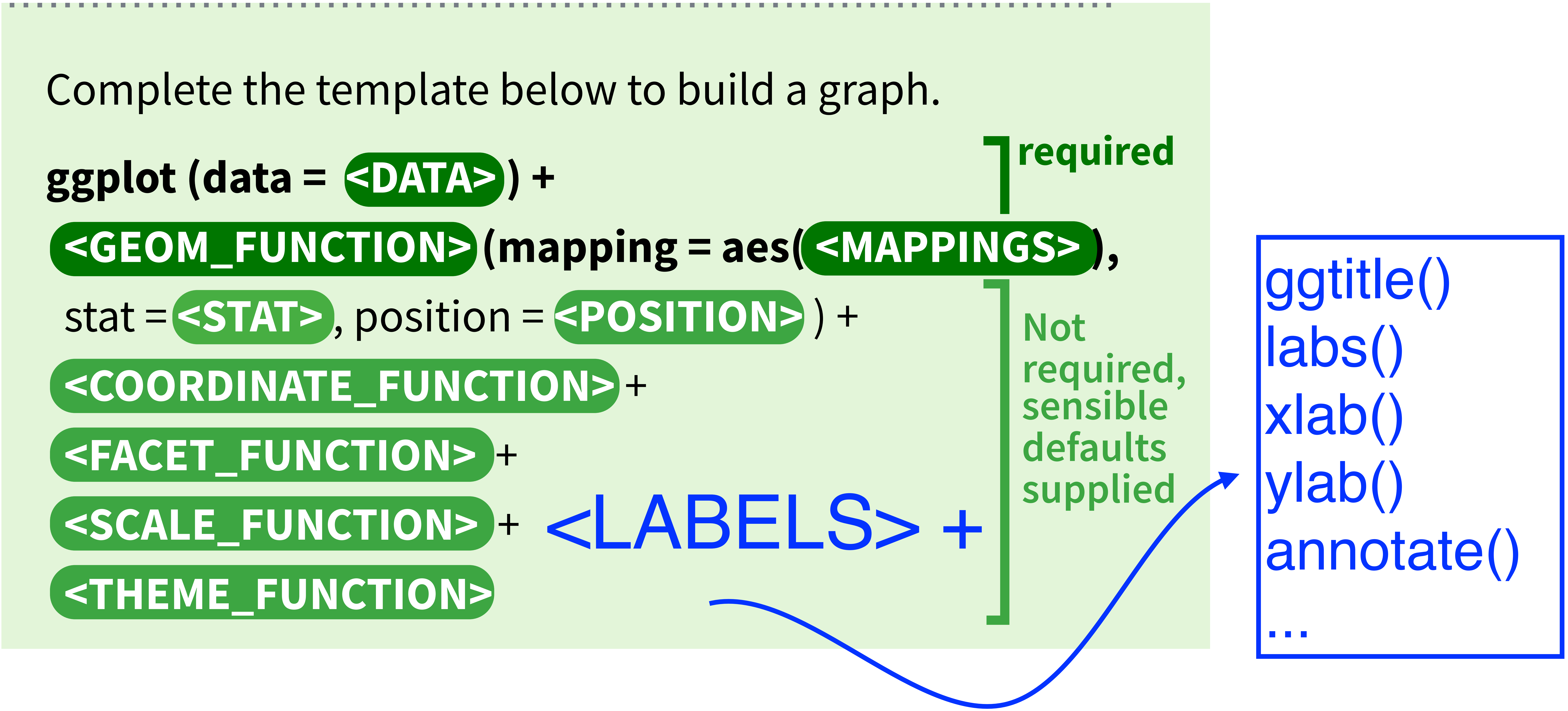
```
ggplot (data = <DATA>) +
<GEOM_FUNCTION>(mapping = aes(<MAPPINGS>),
 stat = <STAT>, position = <POSITION>) +
<COORDINATE_FUNCTION> +
<FACET_FUNCTION> +
<SCALE_FUNCTION> +
<THEME_FUNCTION>
```

required

Not required, sensible defaults supplied

keep this order

code style



Complete the template below to build a graph.

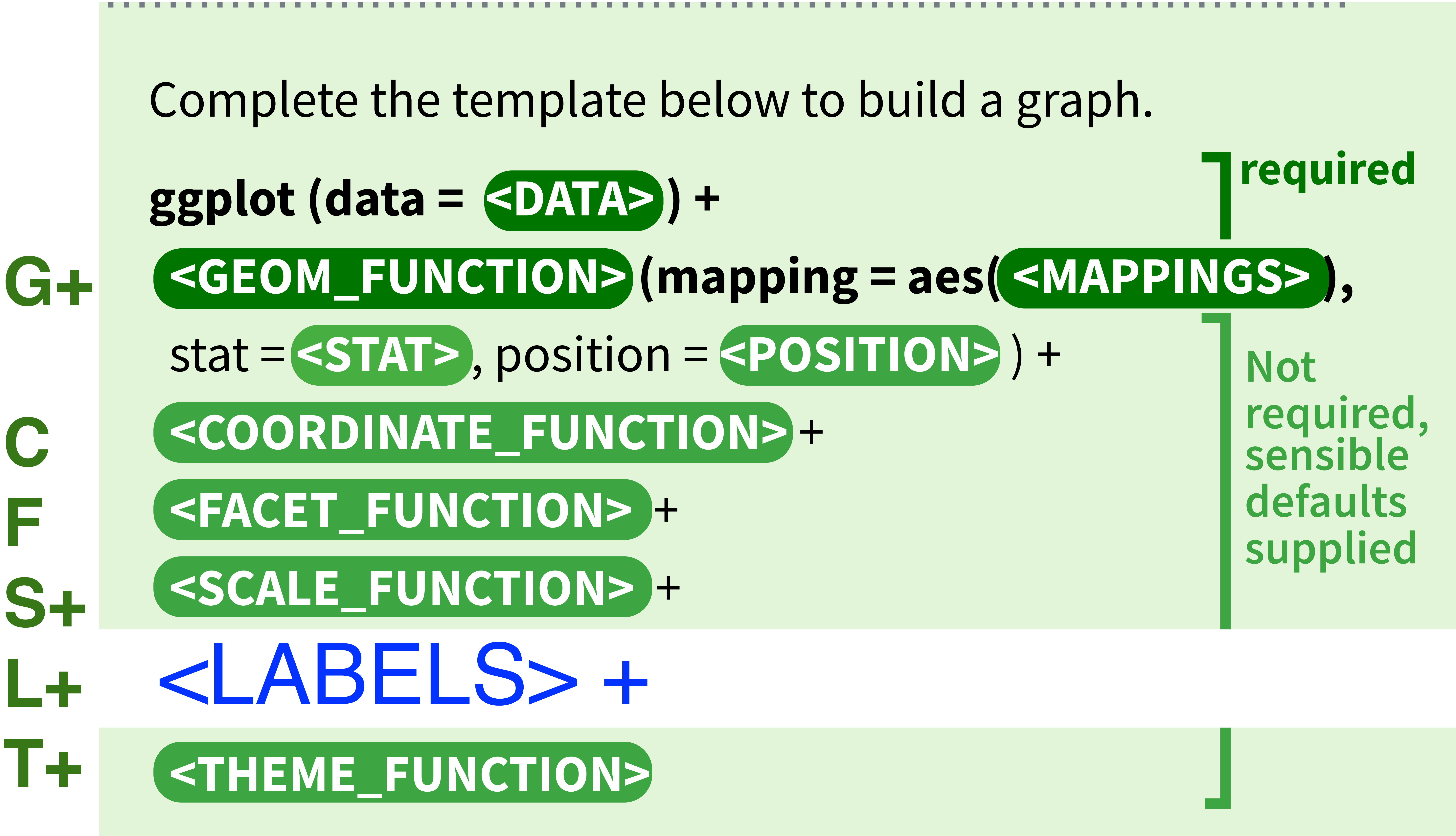
```
ggplot (data = <DATA>) +
<GEOM_FUNCTION>(mapping = aes(<MAPPINGS>),
 stat = <STAT>, position = <POSITION>) +
<COORDINATE_FUNCTION> +
<FACET_FUNCTION> +
<SCALE_FUNCTION> + <LABELS> +
<THEME_FUNCTION>
```

required

Not required, sensible defaults supplied

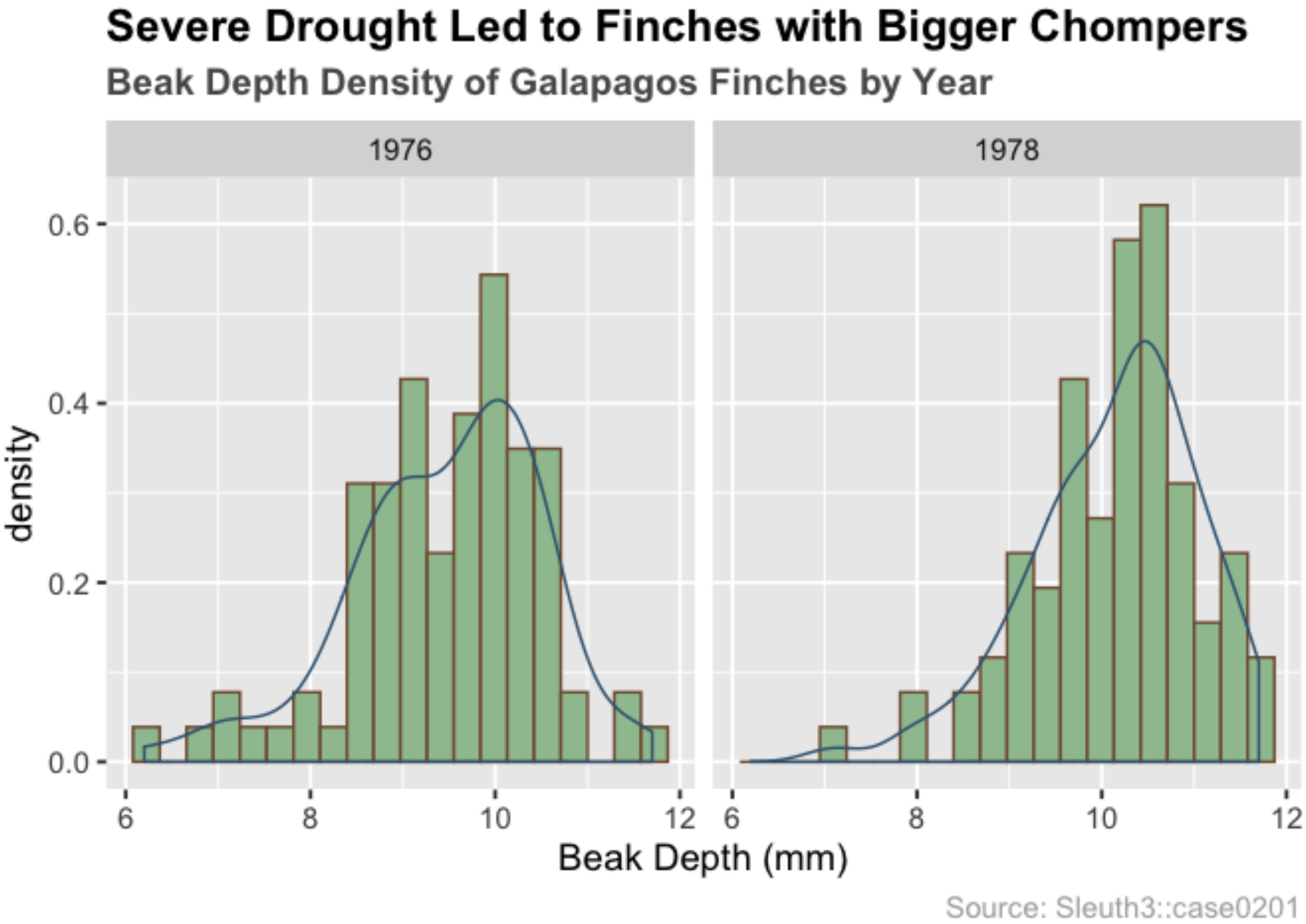
ggtitle()
labs()
xlab()
ylab()
annotate()
...

code style



Complete the template below to build a graph.

```
      ggplot (data = <DATA>) +                                      required
G+    <GEOM_FUNCTION>(mapping = aes(<MAPPINGS>),
       stat = <STAT>, position = <POSITION> ) +                     Not
C     <COORDINATE_FUNCTION> +                                       required,
F     <FACET_FUNCTION> +                                            sensible
S+    <SCALE_FUNCTION> +                                            defaults
L+    <LABELS> +                                                    supplied
T+    <THEME_FUNCTION>
```

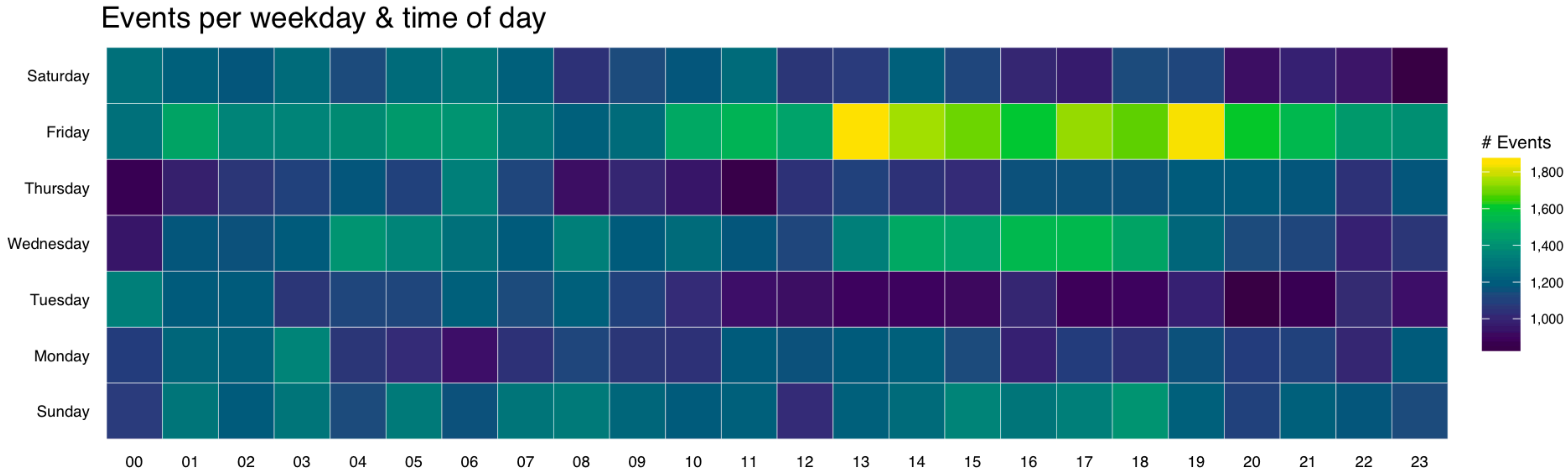


edav.info/histo.html#tldr

code style: every line ends with a "+"

```
    library(Sleuth3) # data
    library(ggplot2)
    finches <- Sleuth3::case0201
    ggplot(finches, aes(x = Depth, y = ..density..)) +
      geom_histogram(bins = 20, colour = "#80593D", fill = "#9FC29F",
G+             boundary = 0) +
C     geom_density(color = "#3D6480") +
S+F   facet_wrap(~Year) +
L+    ggtitle("Severe Drought Led to Finches with Bigger Chompers",
          subtitle = "Beak Depth Density of Galapagos Finches by Year") +
      labs(x = "Beak Depth (mm)", caption = "Source: Sleuth3::case0201") +
T+    theme_grey(14) +
      theme(plot.title = element_text(face = "bold")) +
      theme(plot.subtitle = element_text(face = "bold", color = "grey35")) +
      theme(plot.caption = element_text(color = "grey68"))
```

Building block approach



https://rud.is/b/2016/02/14/making-faceted-heatmaps-with-ggplot2/