FE8828 Programming Web Applications in Finance

Week 4: 9. ggplot2: Data Visualization and EDA

Dr. Yang Ye yy@runchee.com

Nanyang Business School

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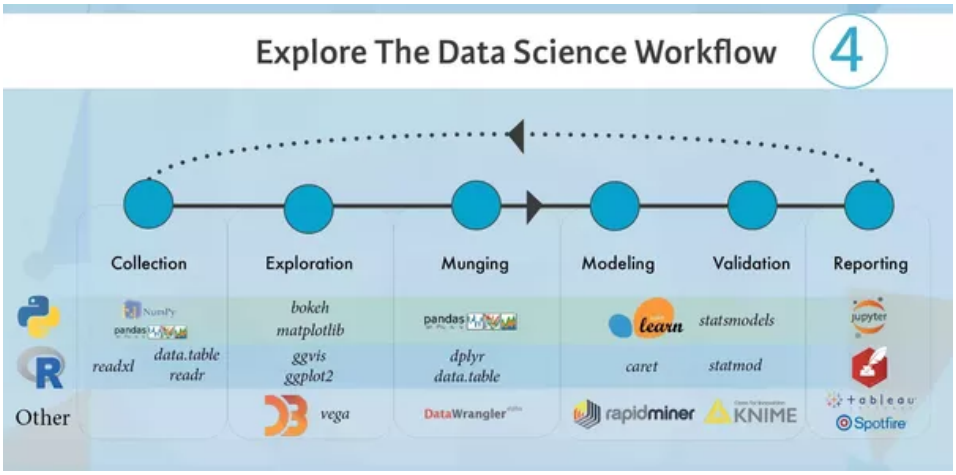
Section 1

Lecture 9: Data Visualization and EDA

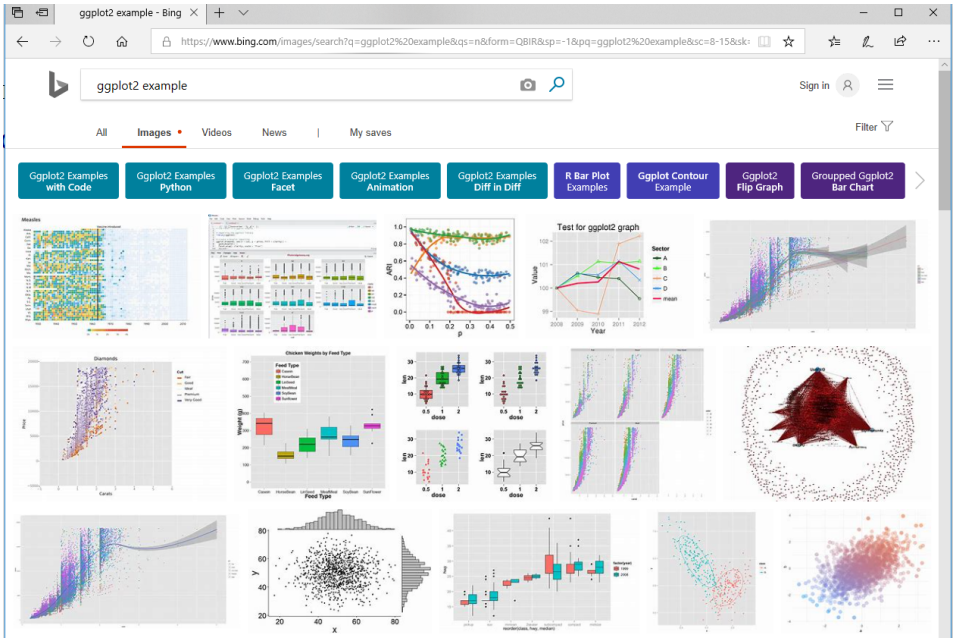
Why do we need ggplot?

Visualizations is part of the data exploration.



ggplot2

- `library(ggplot)`, author Hadley Wickham. First release on June 10, 2007.
- gg stands for "Grammar of Graphics"

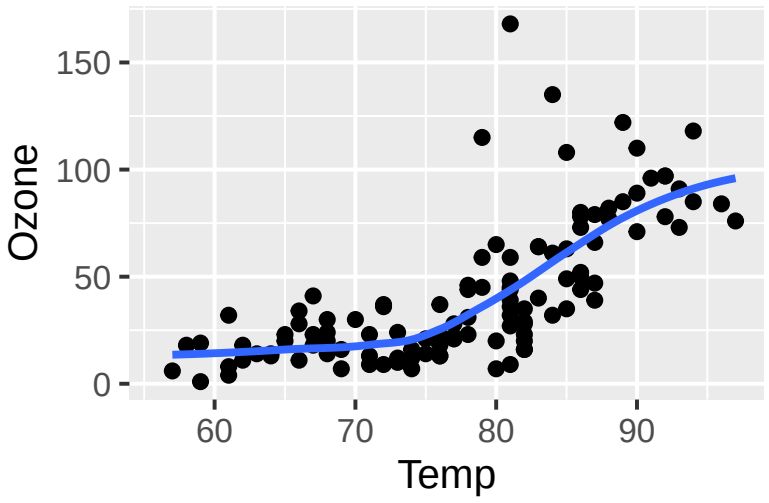


ggplot2 in news

https://qz.com/1007328/all-hail-ggplot2-the-code-powering-all-those-excellent-charts-is-10-years-old/

Programming ggplot2

```
# library(ggplot2)
ggplot(airquality, aes(Temp, Ozone)) +
        geom_point() +
        geom_smooth(method = "loess", se = FALSE)
## `geom_smooth()` using formula 'y ~ x'
## Warning: Removed 37 rows containing non-finite values (stat_smooth).
## Warning: Removed 37 rows containing missing values (geom_point).
```



Syntax of ggplot

- Definition of data + Definitions of layers.

```
# For Single-layer
ggplot(the-data, aes(variable-to-plot)) +
  geom_type-of-graph()

# Or, for multi-layer
ggplot(data = <DATA>, ...) +
  <GEOM_FUNCTION1>(mapping = aes(<MAPPINGS>)) +
  <GEOM_FUNCTION2>(mapping = aes(<MAPPINGS>)) +
  ... +
  other formatting functions.
```


Syntax of ggplot: Points to Note

- Put the + sign in the end of the line, not the beginning of the line.

```
# Below would result in error
ggplot(data = <DATA>, ...)
+ <GEOM_FUNCTION>(mapping = aes(<MAPPINGS>))
```

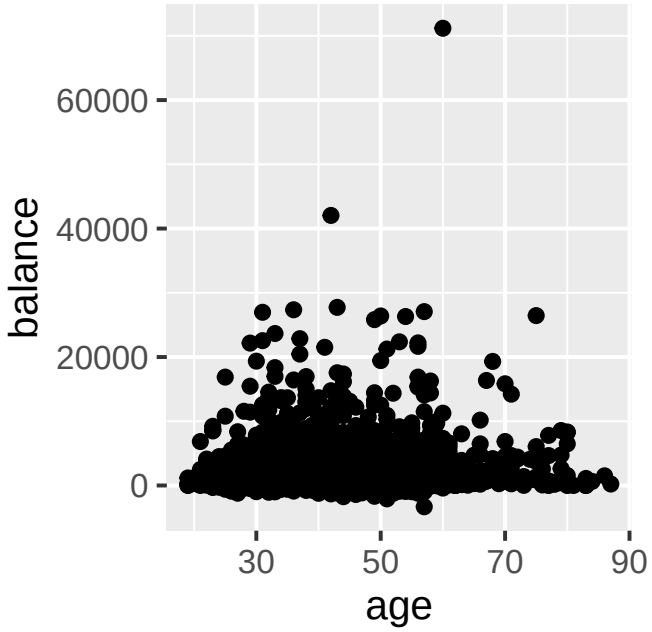
- The definition of data will pass down through the layers. But each layer can have its own data.

```
ggplot(data = d1, ...) +
  geom_point() + # this would get data = d1
  geom_point(data = d2, ...) # this would get data = d2
```

- `geom_point()` is for points, `geom_line()` is for line, `geom_smooth()` for smoothed line... There are many geom-etry.

Simple plot: x and y

```
ggplot(bank, aes(age, balance)) + geom_point()
```



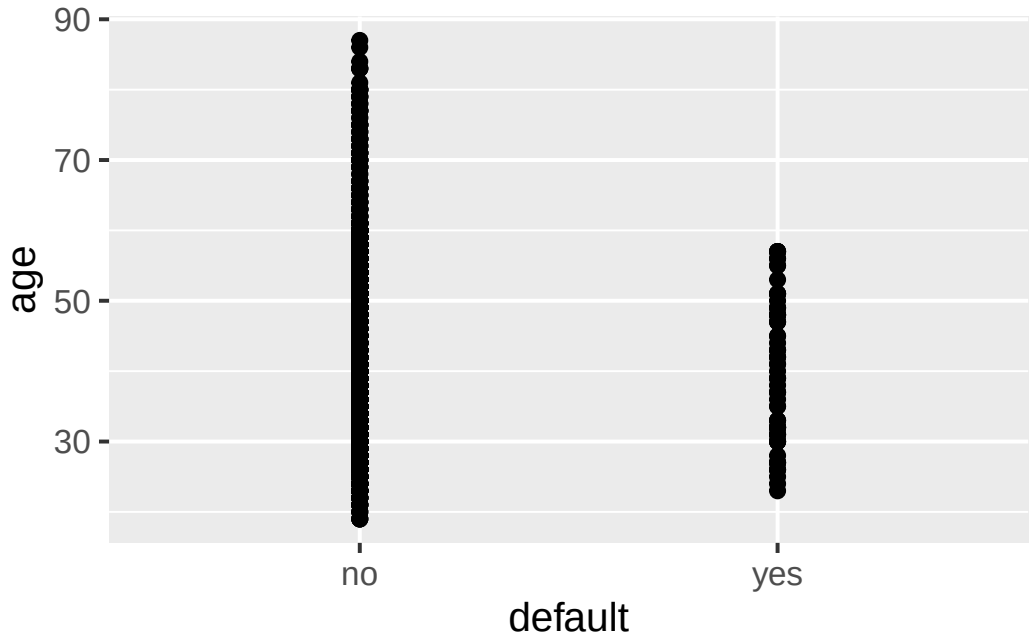
Learning Points for ggplot

- Viz for non-numeric data
- Adjustment
- A few tactics
  - Multiple geoms
  - Pass aes down or not
  - aes and aes_string
- Layers
- Differentiate groups
- Viz for numeric data

For non-numeric data: default and age

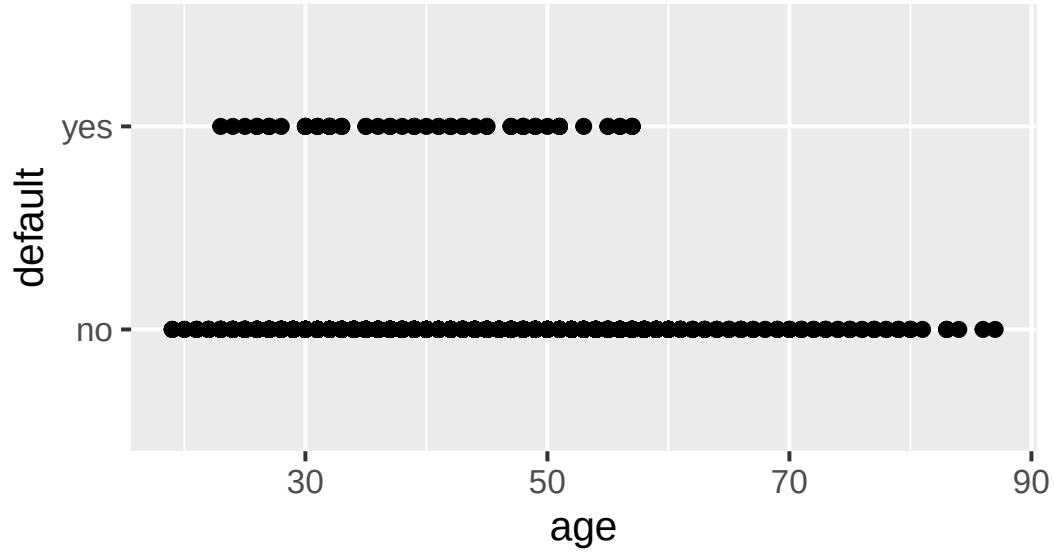
```
ggplot(bank, aes(default, age)) + geom_point()
ggplot(bank, aes(age, default)) + geom_point()
ggplot(bank, aes(job, age)) + geom_point()
```

```
ggplot(bank, aes(default, age)) + geom_point()
```



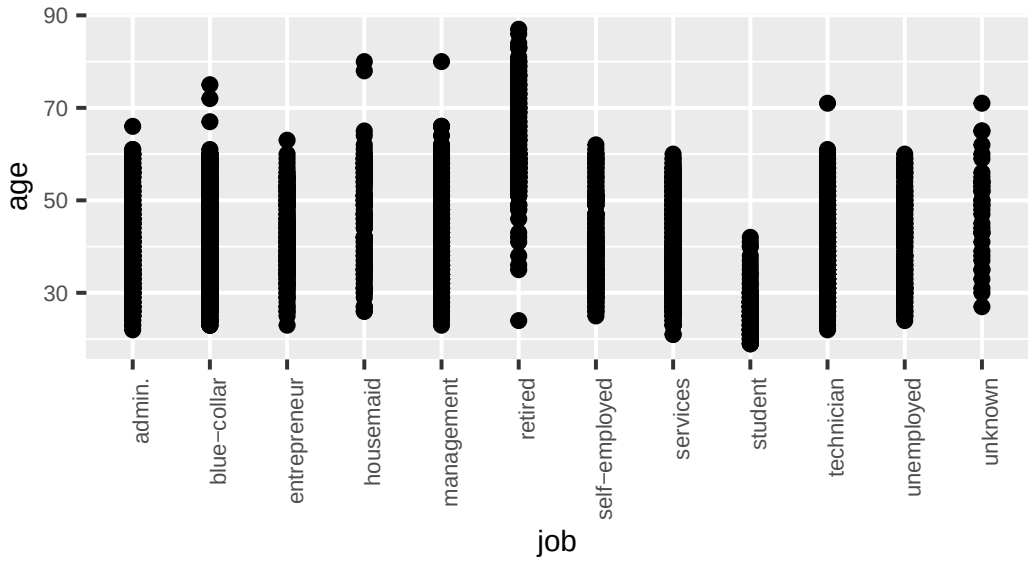
For non-numeric data: age and default (make it landscape)

```
ggplot(bank, aes(age, default)) + geom_point()
```



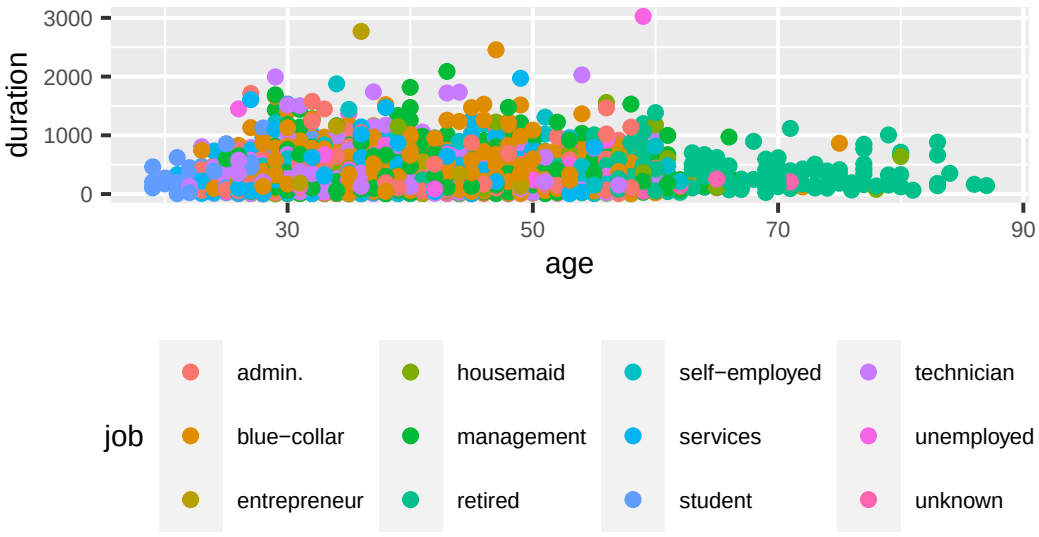
For non-numeric data: job and age

```
ggplot(bank, aes(job, age)) + geom_point() +
  theme(text = element_text(size=8),
        axis.text.x = element_text(angle=90, hjust=1))
```



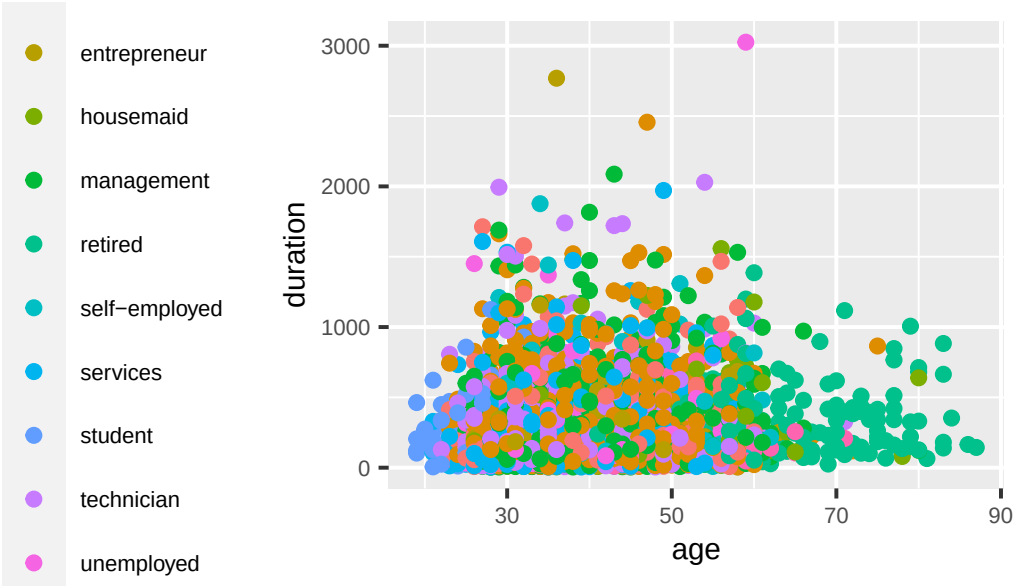
Adjustment: legend bottom

```
# adjust legend position
ggplot(bank, aes(x = age, y = duration, color = job)) +
geom_point() +
theme(legend.position="bottom", text = element_text(size=8))
```



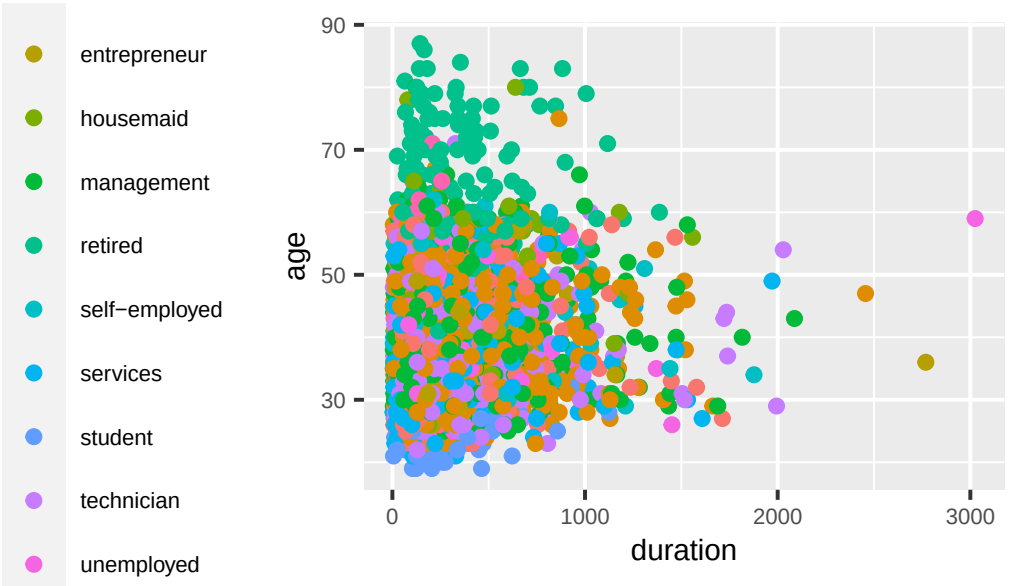
Adjustment: legend left

```
# legend to the left
ggplot(bank, aes(x = age, y = duration, color = job)) +
geom_point() +
theme(legend.position="left", text = element_text(size=8))
```



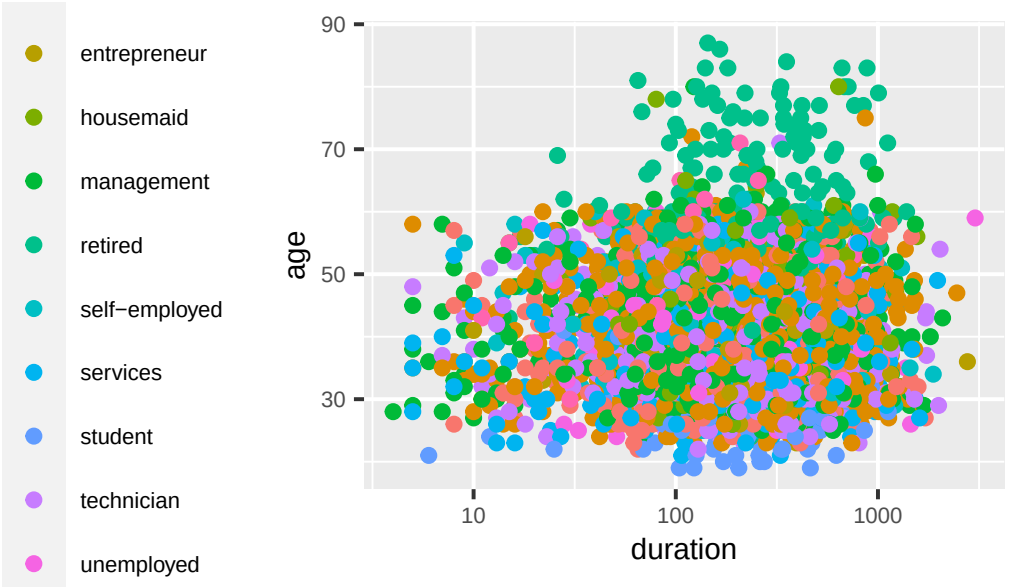
Adjustment: coordinate flip

```
# Flip the x and y axis
# Different feeling?
ggplot(bank, aes(x = age, y = duration, color = job)) +
geom_point() +
theme(legend.position="left", text = element_text(size=8)) +
coord_flip()
```



Adjustment: log scale

```
# Make y as log scaled.
# Note that before flip, x is y, so we use scale_y_log10()
ggplot(bank, aes(x = age, y = duration, color = job)) +
geom_point() +
theme(legend.position="left", text = element_text(size=8)) +
coord_flip() +
scale_y_log10()
```

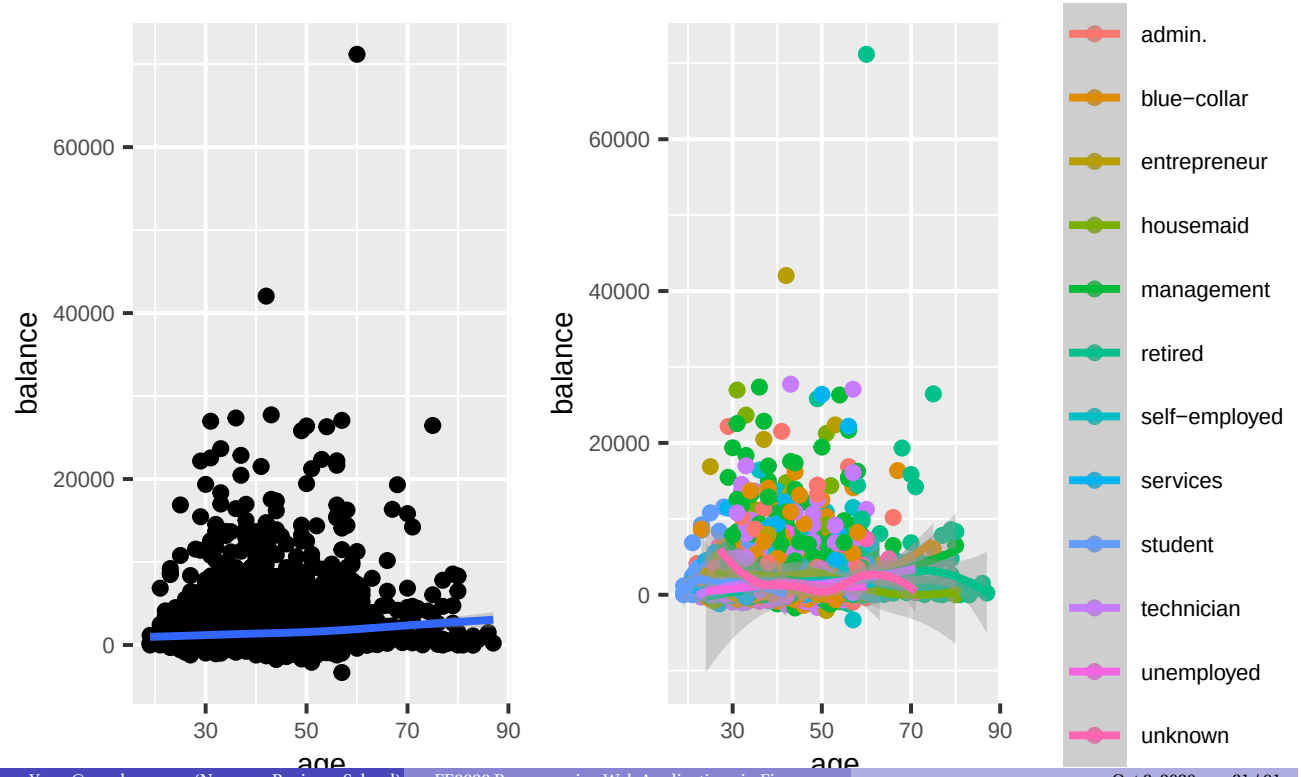


Add 2nd geometry

```
ggplot(bank, aes(age, balance)) + geom_point() + geom_smooth()
ggplot(bank, aes(age, balance, color = job)) + geom_point() + geom_smooth()
```

Add 2nd geometry - Plot

```
## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'
## `geom_smooth()` using method = 'loess' and formula 'y ~ x'
```



Multiple geoms: Pass aes down

`geom_*` functions has a default parameter of `inherit.aes = TRUE`.

```
ggplot(bank, aes(x = age, y = duration)) +
geom_smooth() + # same as geom_smooth(aes(x = age, y = duration))
geom_point() # same as geom_point(aes(x = age, y = duration))
```

```
# This is equivalent to below. But this is a bit repeating.
ggplot(bank) +
geom_point(aes(x = age, y = duration)) +
geom_smooth(aes(x = age, y = duration))
```

Pass aes down or not: Case of Not

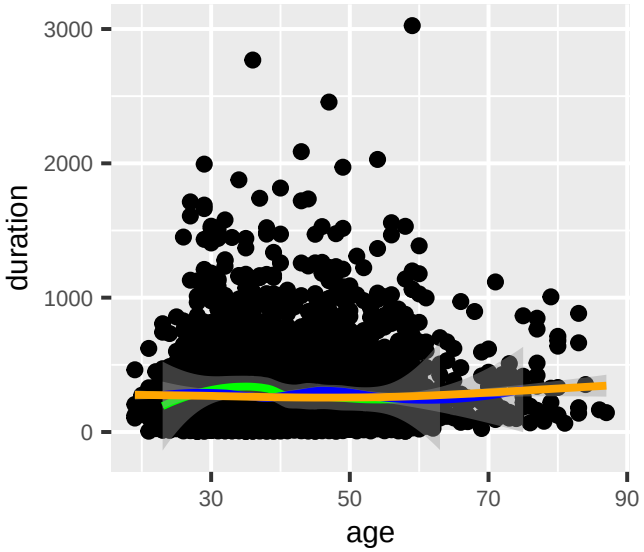
Some cases, we do need to have different data and aes on layers for different `geom_*` functions.

```
ggplot(bank) +
geom_point(aes(x = age, y = duration)) +
geom_smooth(data = filter(bank, job == "entrepreneur"),
            aes(x = age, y = duration), color = "green") +
geom_smooth(data = filter(bank, job == "blue-collar"),
            aes(x = age, y = duration), color = "blue") +
geom_smooth(data = filter(bank, job != "entrepreneur"),
            aes(x = age, y = duration), color = "orange") +
```


Pass aes down or not: Case of Not - Result

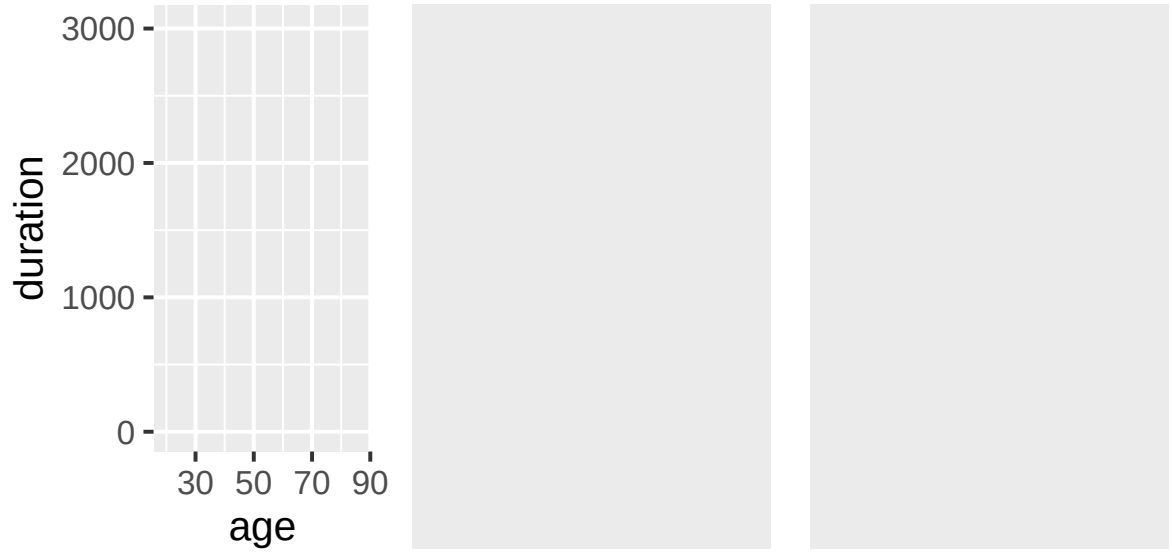
I added `theme(text = element_text(size=8))` to many ggplot statement. This is to fit to the slide size. You may NOT need it in a R Markdown.

```
## `geom_smooth()` using method = 'loess' and formula 'y ~ x'
## `geom_smooth()` using method = 'loess' and formula 'y ~ x'
## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'
```



Each + is a layer

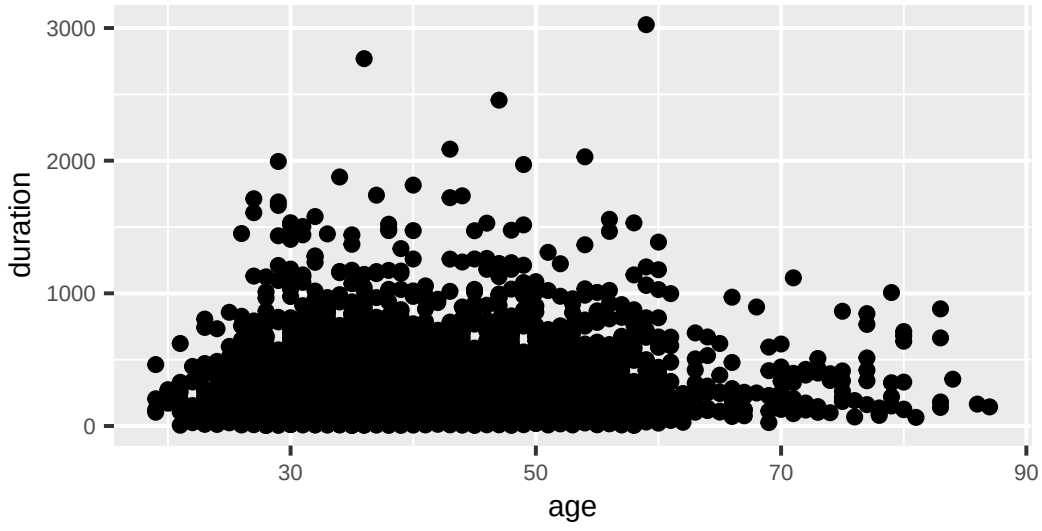
```
# Nearly empty chart.
g <- ggplot(bank, aes(x = age, y = duration))
# This is almost empty
g <- ggplot(bank)
# This is really empty.
g <- ggplot()
```



Combine g with layers

```
ggplot(bank, aes(x = age, y = duration)) + theme(text = element_text(size=8)) +
  geom_point() + geom_smooth()
```

```
# This is equivalent to above
g <- ggplot(bank, aes(x = age, y = duration)) + theme(text = element_text(size=8))
g + geom_point()
```




```
g + geom_line()
```

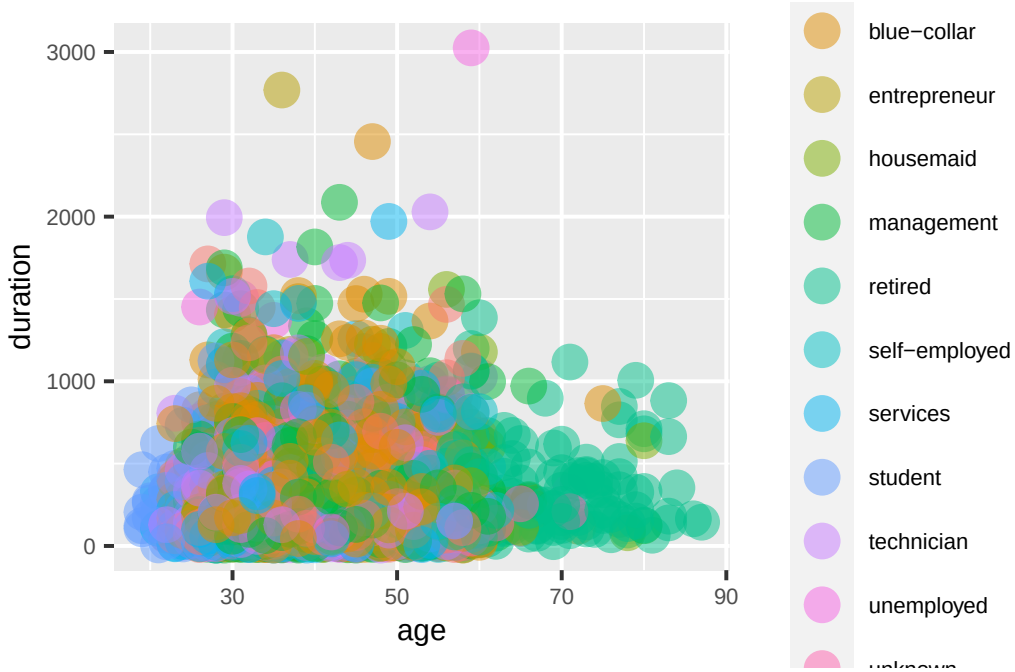
g can be re-used

- g can be re-used. It's good to be used when we want to explorer data and try to plot many figures.
- Fixed a few variables in `g <- ggplot(data, aes(job, balance))`.
- Use `g + geom_XXX()` to find the best representation for the relationship between variables.

```
g <- ggplot(bank, aes(job, balance))
g + geom_point()
g + ()
```

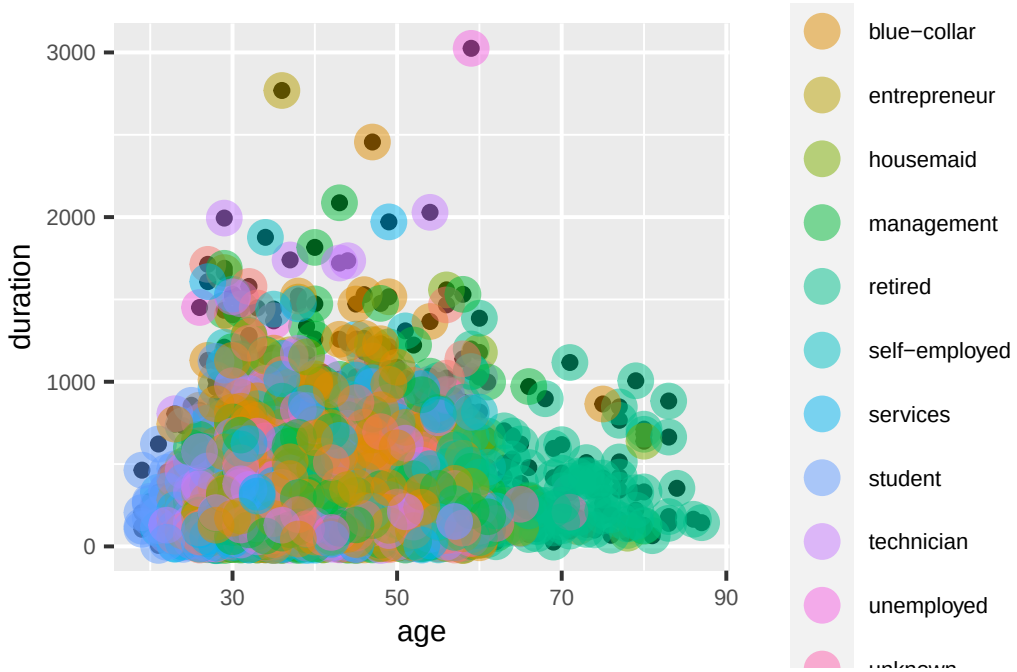

g: mix and match: which figure?

```
1. g + geom_point() + geom_smooth(method = "lm") + facet_grid(. ~ job)
2. g + geom_point(color = "steelblue", size = 4, alpha = 1/2)
3. g + geom_point(aes(color = job), size = 4, alpha = 1/2)
4. g + geom_point() + geom_point(aes(color = job), size = 4, alpha = 1/2)
```



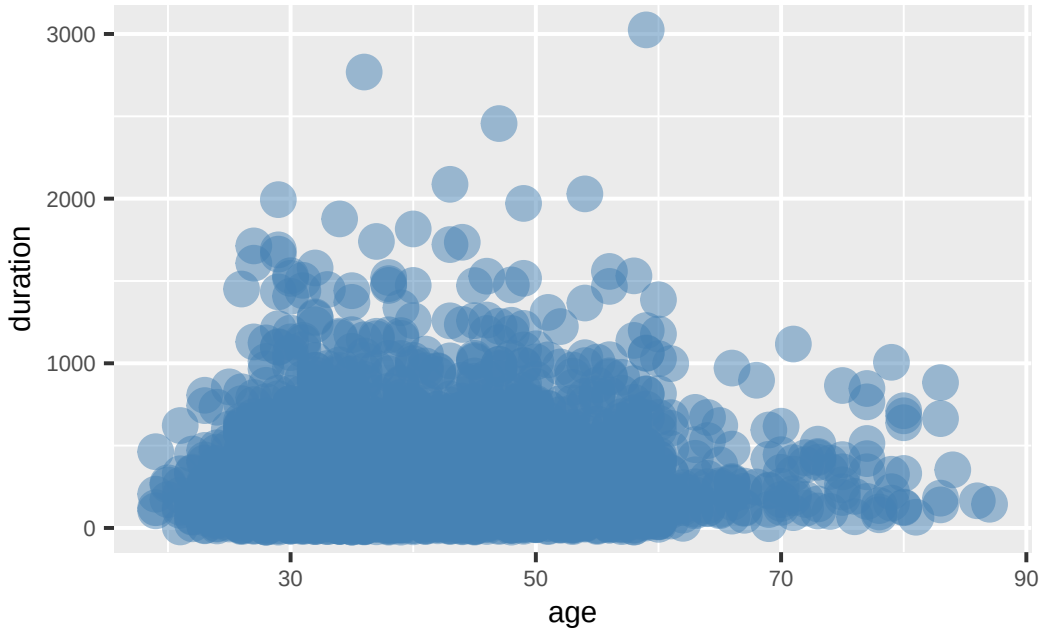
g: mix and match: which figure?

```
1. g + geom_point() + geom_smooth(method = "lm") + facet_grid(. ~ job)
2. g + geom_point(color = "steelblue", size = 4, alpha = 1/2)
3. g + geom_point(aes(color = job), size = 4, alpha = 1/2)
4. g + geom_point() + geom_point(aes(color = job), size = 4, alpha = 1/2)
```



g: mix and match: which figure?

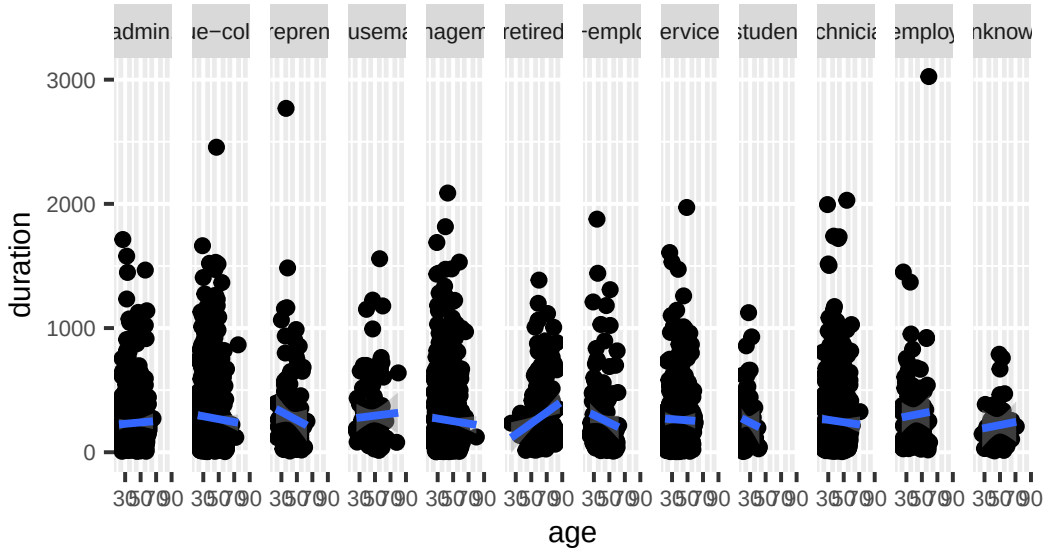
```
1. g + geom_point() + geom_smooth(method = "lm") + facet_grid(. ~ job)
2. g + geom_point(color = "steelblue", size = 4, alpha = 1/2)
3. g + geom_point(aes(color = job), size = 4, alpha = 1/2)
4. g + geom_point() + geom_point(aes(color = job), size = 4, alpha = 1/2)
```



g: mix and match: which figure?

```
1. g + geom_point() + geom_smooth(method = "lm") + facet_grid(. ~ job)
2. g + geom_point(color = "steelblue", size = 4, alpha = 1/2)
3. g + geom_point(aes(color = job), size = 4, alpha = 1/2)
4. g + geom_point() + geom_point(aes(color = job), size = 4, alpha = 1/2)
```

```
## `geom_smooth()` using formula 'y ~ x'
```



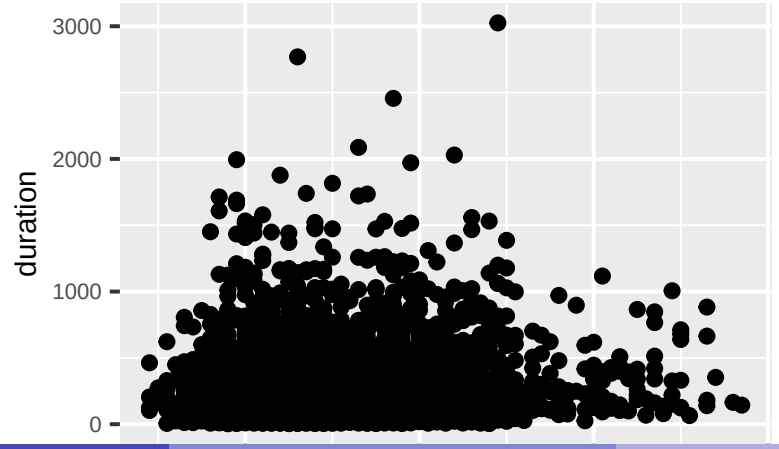
aes and aes_string

- aes needs to have fixed column names. use aes_string to pass variable name as string.

```
ggplot(bank, aes_string("age", "balance", color = "job")) + geom_point()
```

Example of aes_string

```
# Instead of, ggplot(bank, aes(age, balance)) + geom_point()
plot_bank <- function(x, y) {
  ggplot(bank, aes_string(x, y)) + geom_point() + theme(text = element_text(size=8))
}
plot_bank("age", "duration")
```



Example for `aes_string`

You may use `aes_string` in Shiny app to get user's input.

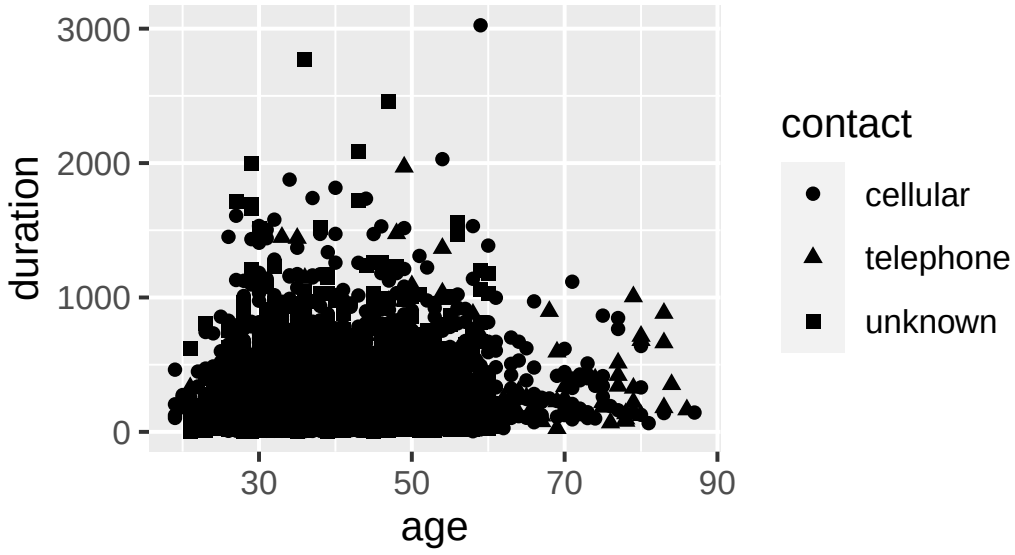
```
# in a Shiny app
# in ui
selectInput("column", "col", choices = c("balance", "duration"))
# in server
plot_bank("age", input$col)
```


Differentiate groups

- shape
- color
- size
- alpha

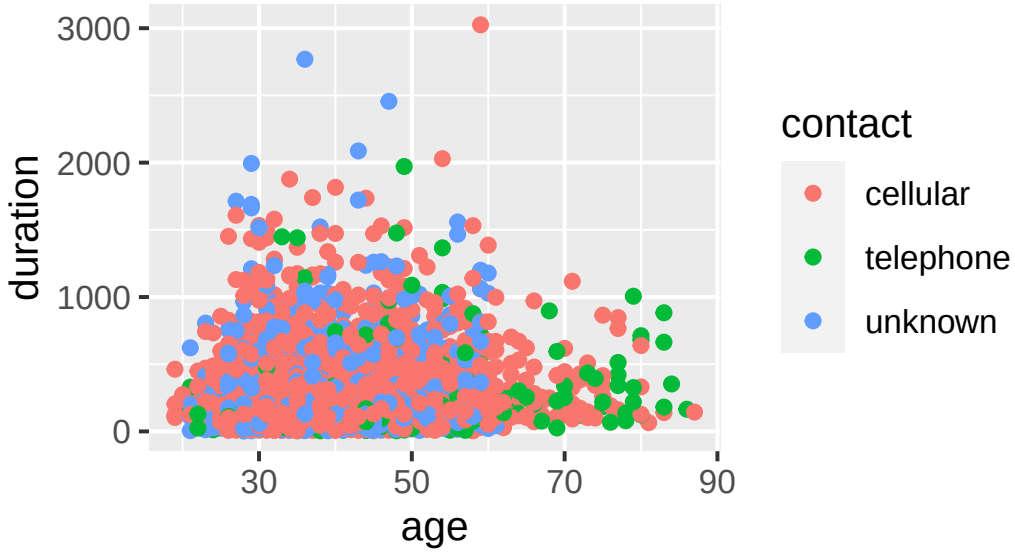
Differentiate groups - shape

```
# Use shape
ggplot(bank) +
  geom_point(aes(age, duration, shape = contact))
```



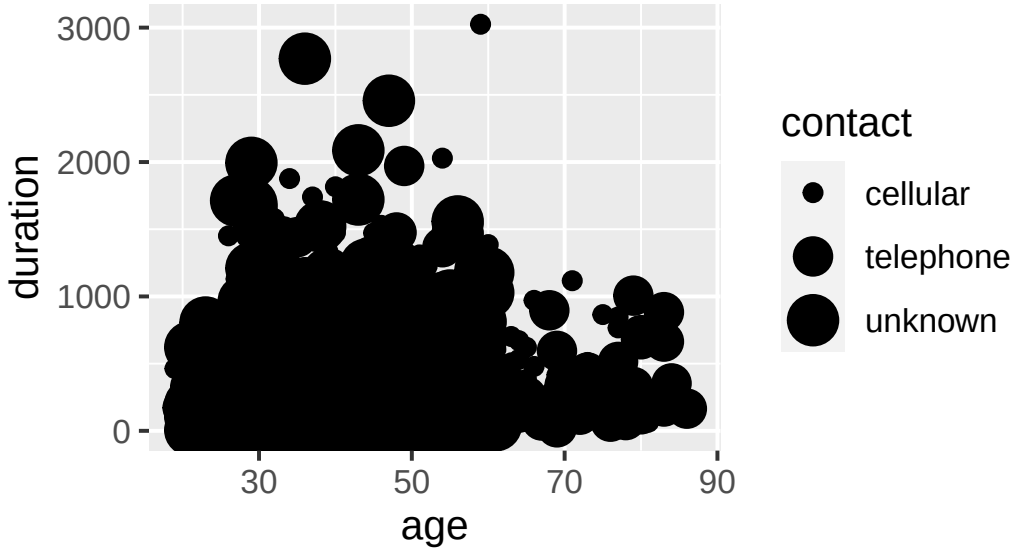
Differentiate groups - color

```
# Use color
ggplot(bank) +
  geom_point(aes(age, duration, color = contact))
```



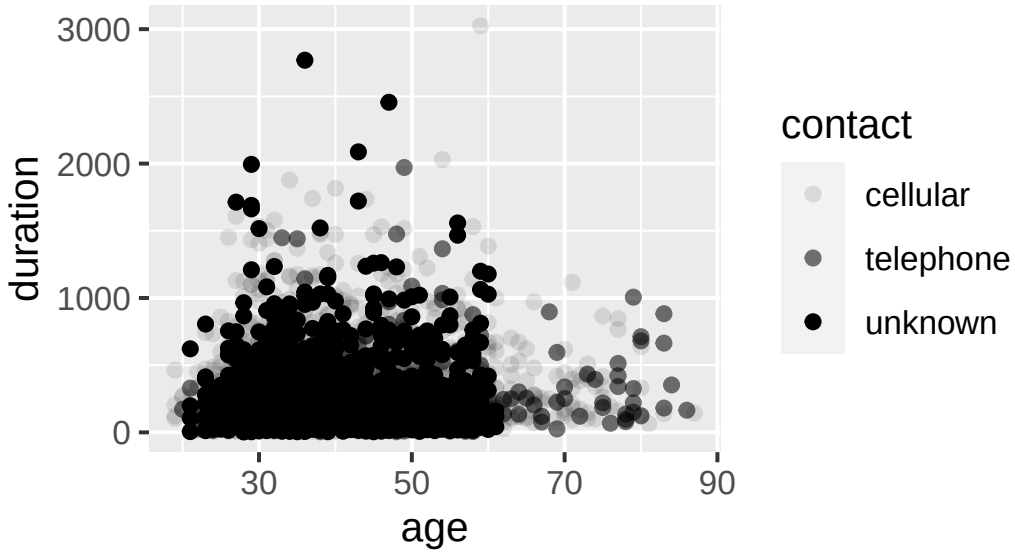
Differentiate groups - size

```
# Use size
ggplot(bank) +
  geom_point(aes(age, duration, size = contact))
## Warning: Using size for a discrete variable is not advised.
```



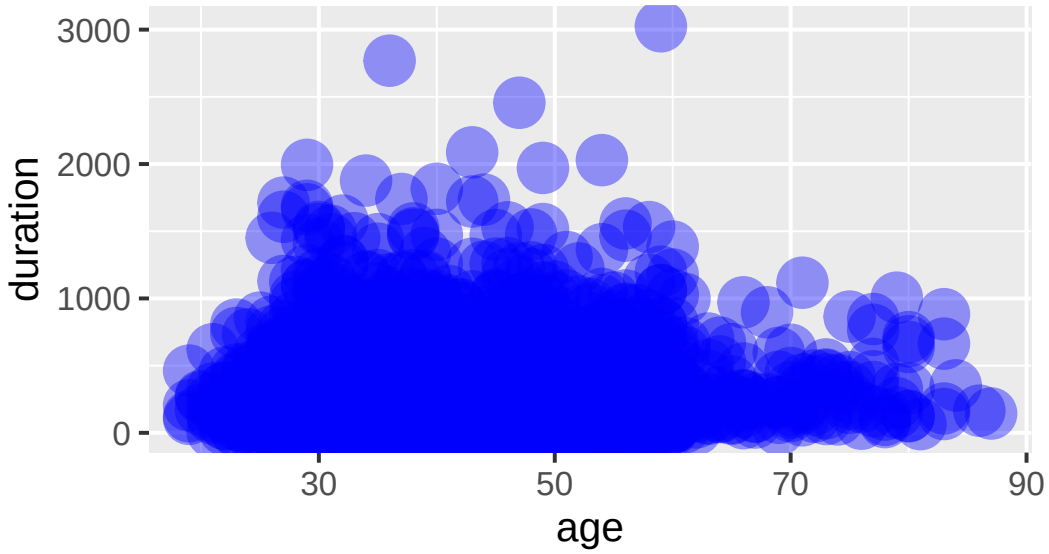
Differentiate groups - alpha

```
# Use alpha - transparency
ggplot(bank) +
  geom_point(aes(age, duration, alpha = contact))
## Warning: Using alpha for a discrete variable is not advised.
```



Enforce color, put things outside aes

```
## you can also enforce color, put things outside aes
ggplot(bank) +
  geom_point(aes(age, duration),
             color = "blue", size = 6, alpha = 0.4)
```



What's inside bank's clients? Things to consider - 1

- Which variables in data are categorical?
- Which variables are continuous?
- Bio:
  - age
  - job
  - marital
  - education
- Financial
  - default
  - balance
  - housing
  - loan

What's inside bank's clients? Things to consider - 2

- Communication
  - contact: celluar v.s. telephone v.s. unknown
  - day/month: maybe good to ignore?
  - duration:
  - campaign:
  - pdays:
  - previous:
  - poutcome:

Categorical/Continuous variable

- numeric -> continuous data
- string -> discrete data

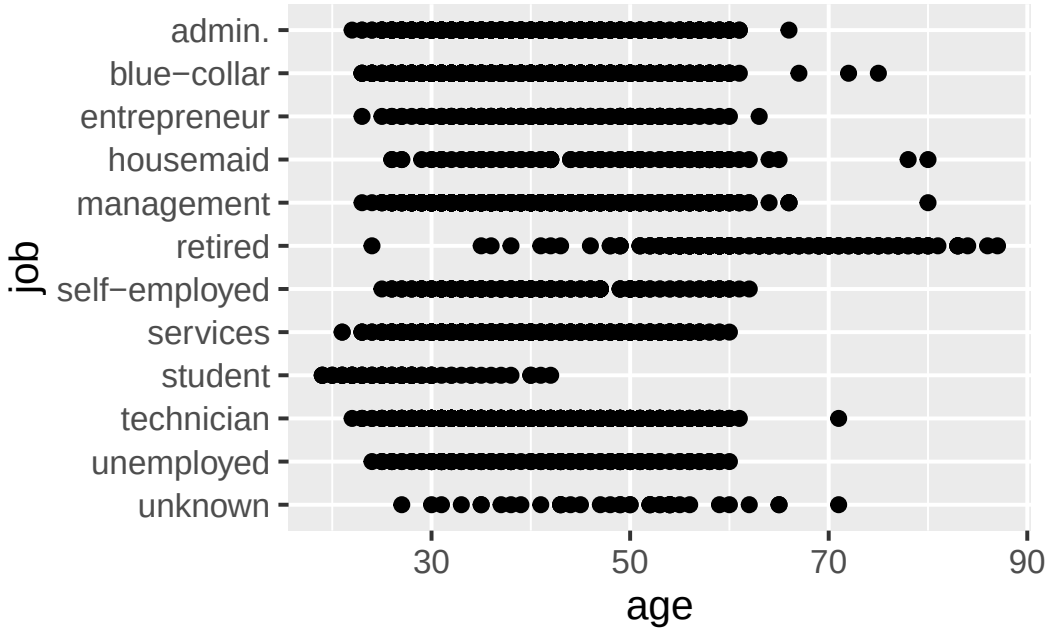
For different type of variables, the scale is also different

- To reverse a categorical (discrete) variable, we use `scale_y_discrete(limit = rev(levels(factor(...))))`.
- To reverse a continuous numerical variable, we use `scale_x_reverse()`.

Exercise

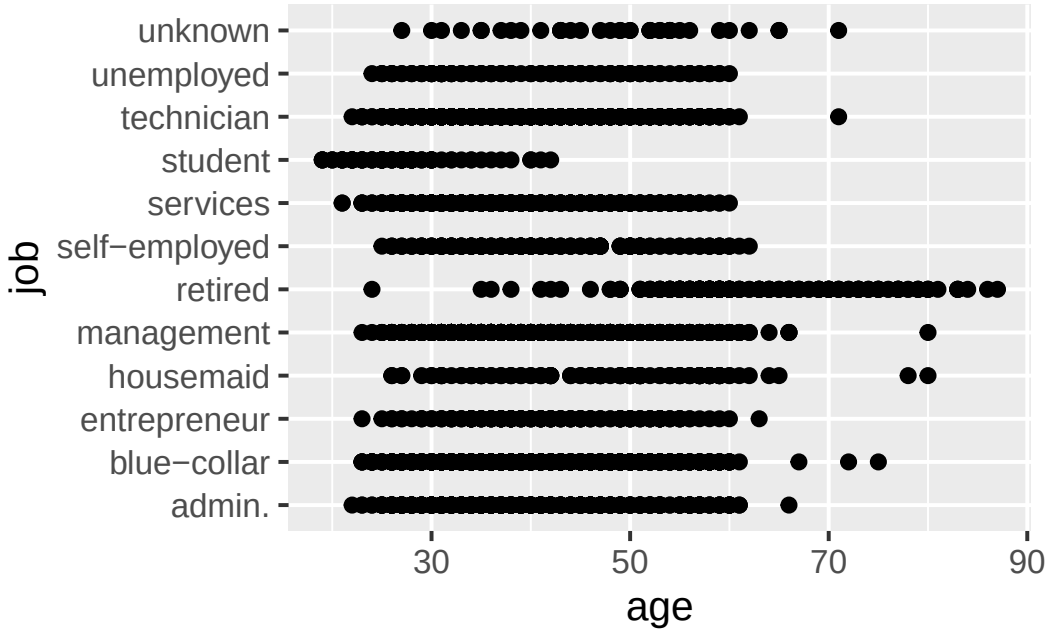
1. What does this figure mean?

```
ggplot(bank, aes(age, job)) +
geom_point() +
scale_y_discrete(limit = rev(levels(factor(bank$job))))
```



Exercise

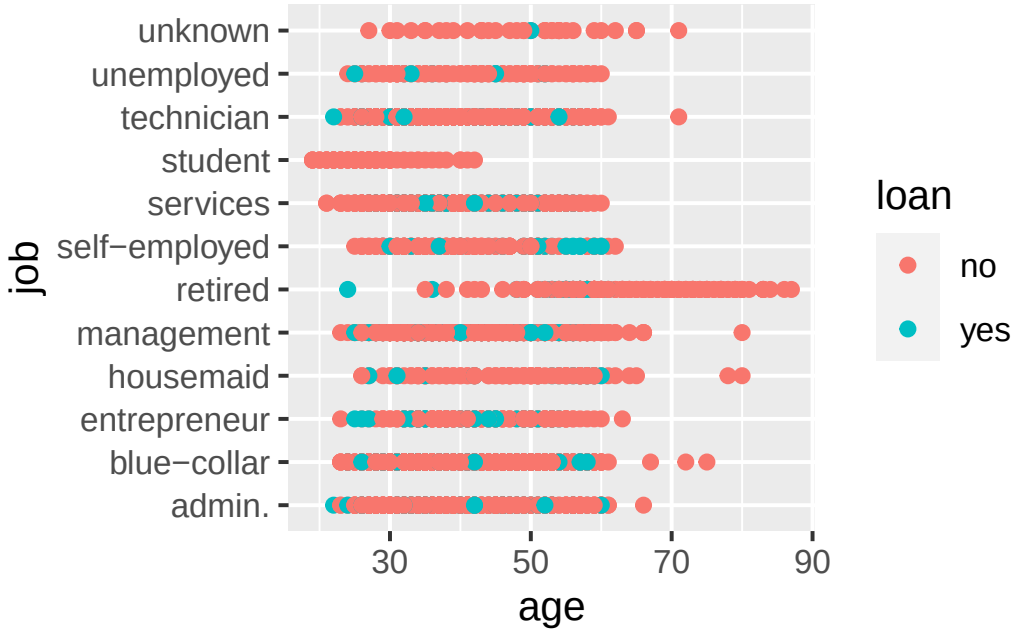
```
# y labels without sort.
ggplot(bank, aes(age, job)) + geom_point()
```



Exercise

2. I tried to plot between job, loan and age. Any better idea?

```
suppressWarnings(
  ggplot(bank, aes(age, job, color = loan)) + geom_point()
)
```

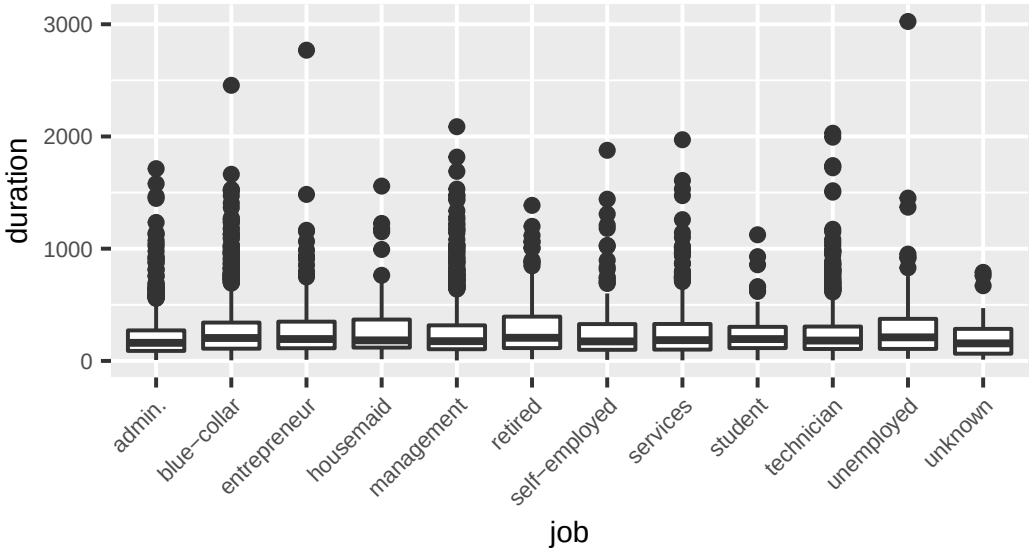


Other geoms

- geom_boxplot()
- geom_density()
- geom_histogram()
- geom_bar()

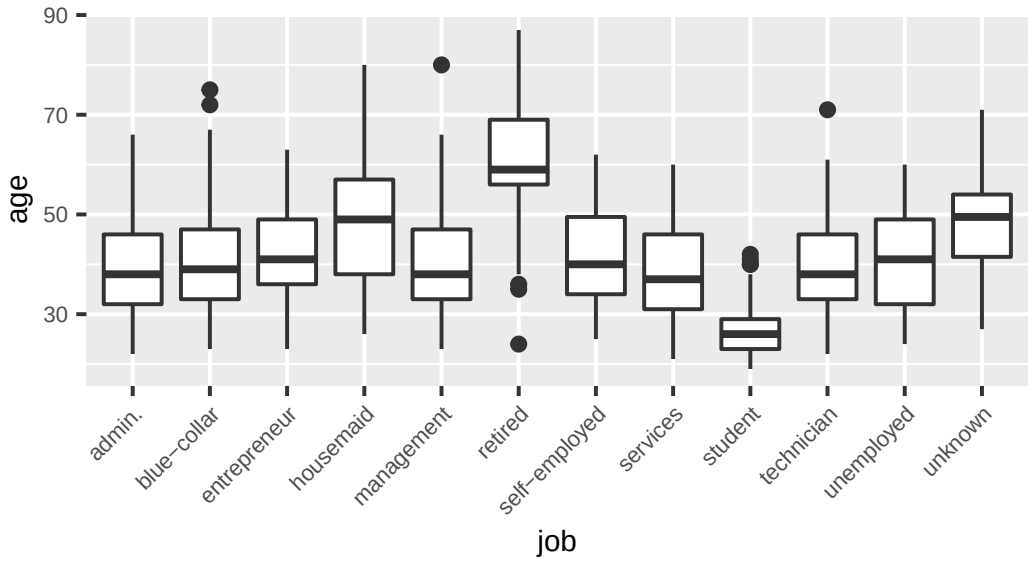
Boxplot: job and duration

```
ggplot(bank, aes(job, duration)) + geom_boxplot() +
  theme(text = element_text(size=8),
        axis.text.x = element_text(angle = 45, hjust = 1))
```



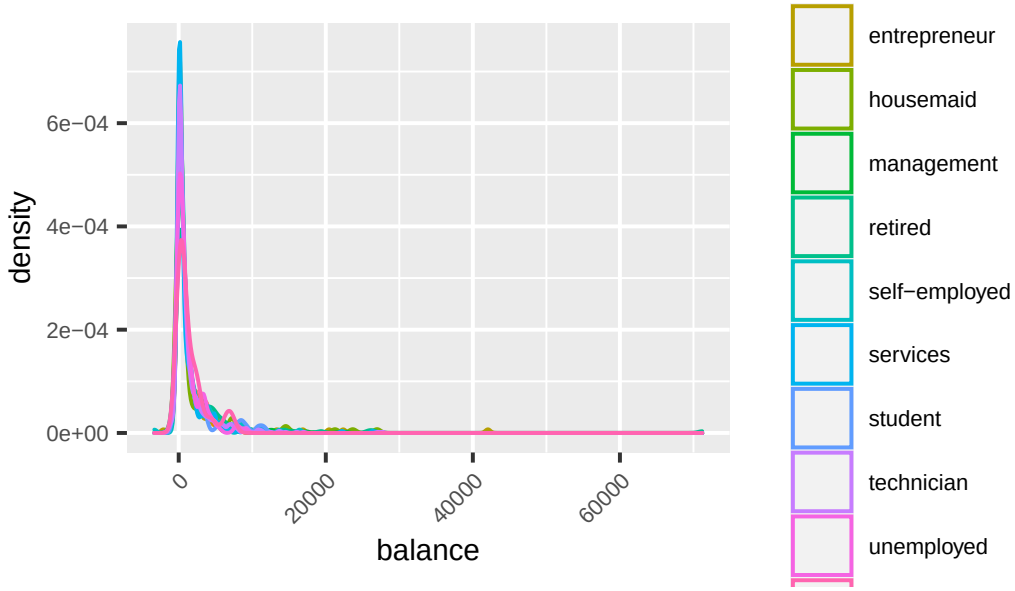
Boxplot: job and age

```
ggplot(bank, aes(job, age)) + geom_boxplot() +
  theme(text = element_text(size=8),
        axis.text.x = element_text(angle = 45, hjust = 1))
```



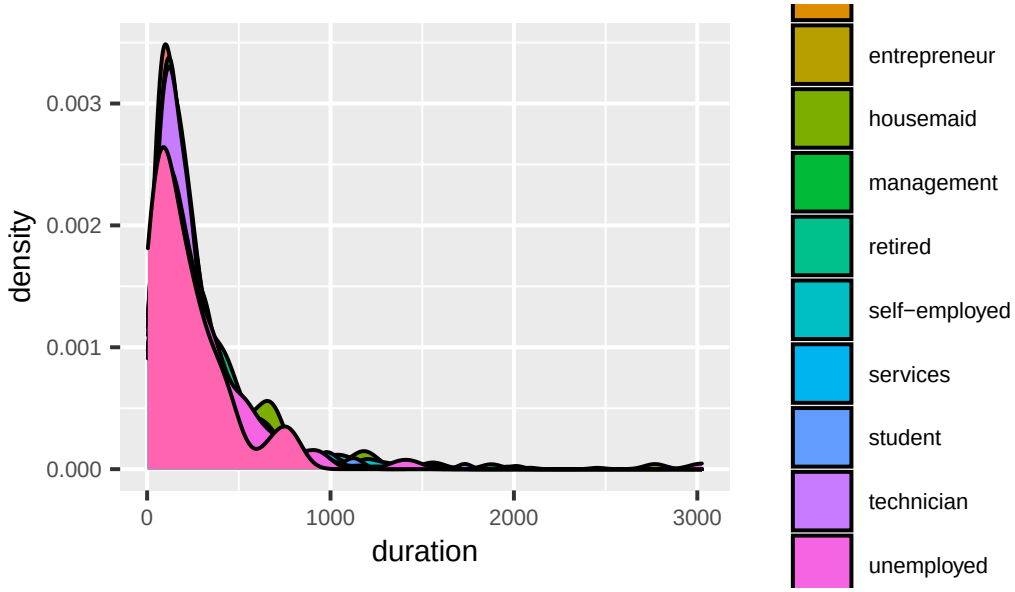
Density: balance and job with color

```
ggplot(bank, aes(balance, color = job)) + geom_density() +
  theme(text = element_text(size=8),
        axis.text.x = element_text(angle = 45, hjust = 1))
```



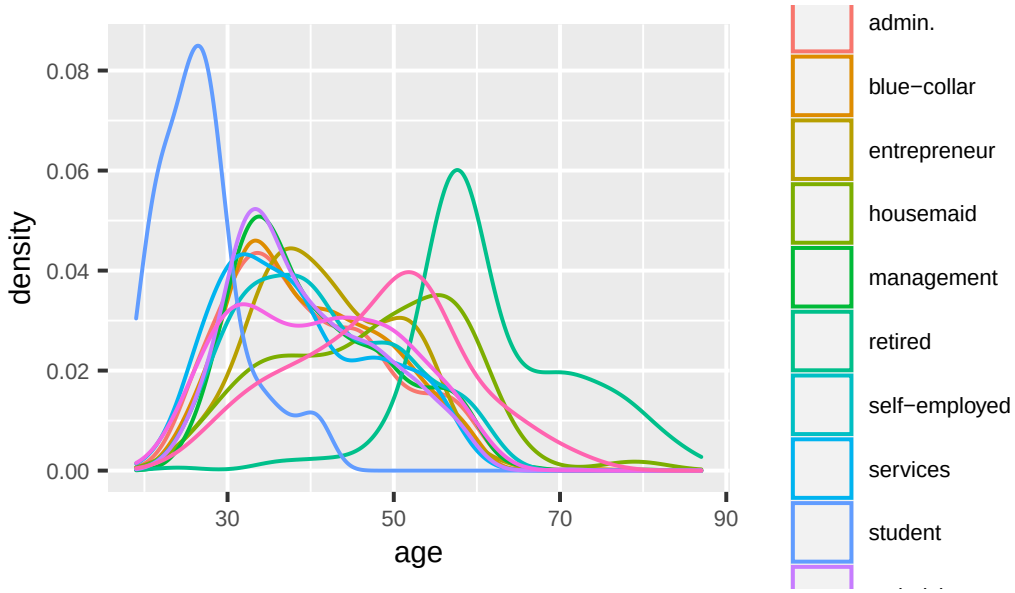
Density: balance and job with fill

```
ggplot(bank, aes(duration, fill = job)) + geom_density() +
  theme(text = element_text(size=8))
```



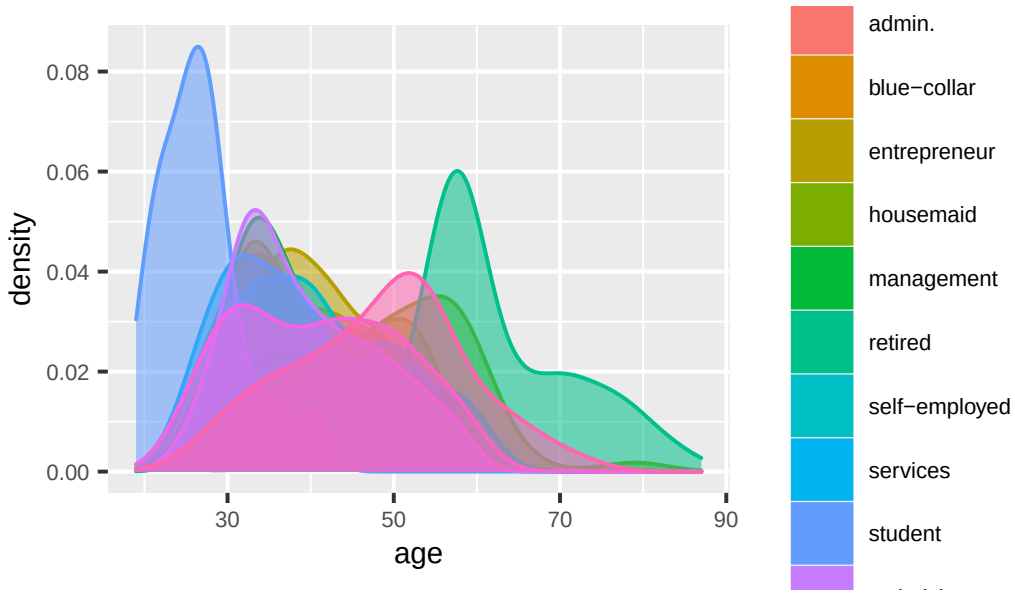
Density: age and job with color and alpha

```
ggplot(bank, aes(age, color = job, alpha = 0.3)) + geom_density() +
  theme(text = element_text(size=8))
```



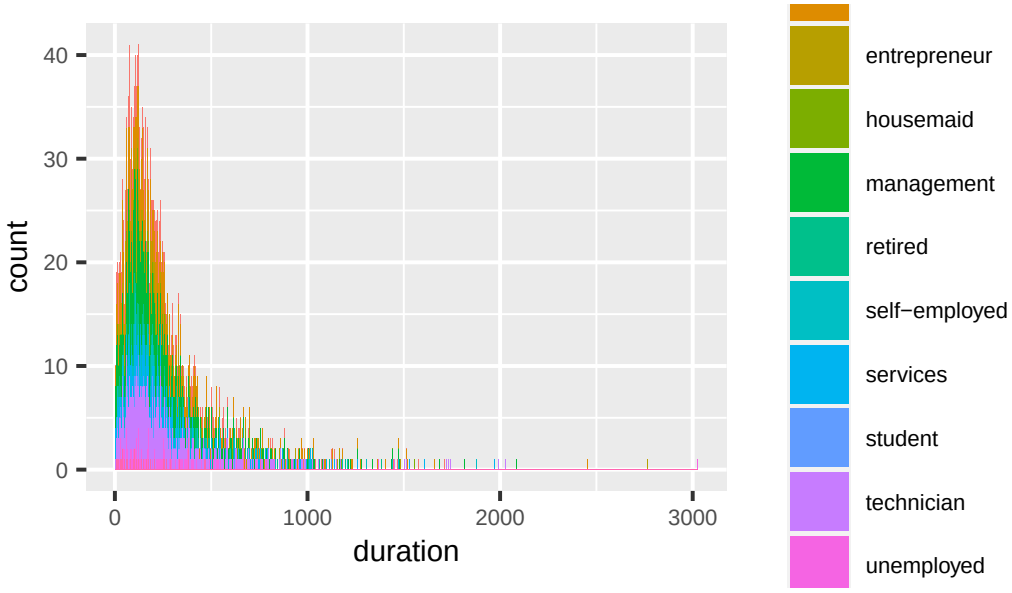
Density: age and job with fill and color and alpha

```
# Which is better?
ggplot(bank, aes(age, color = job, fill = job, alpha = 0.3)) +
  geom_density() + theme(text = element_text(size=8))
```



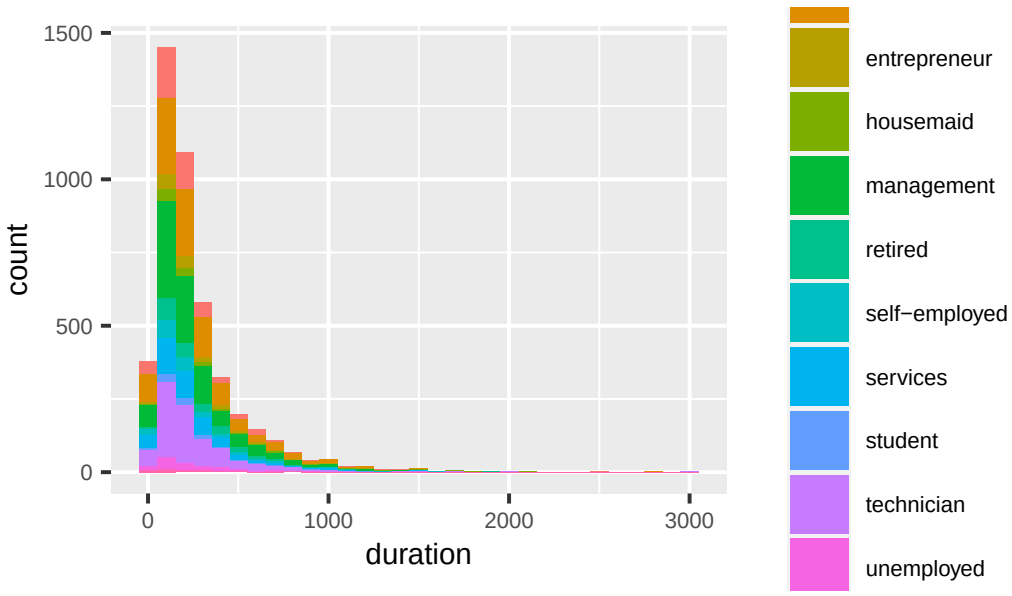
histogram: duration and job and `binwidth = 2`

```
ggplot(data = bank, mapping = aes(x = duration, fill = job)) +
  geom_histogram(binwidth = 2) + theme(text = element_text(size=8))
```



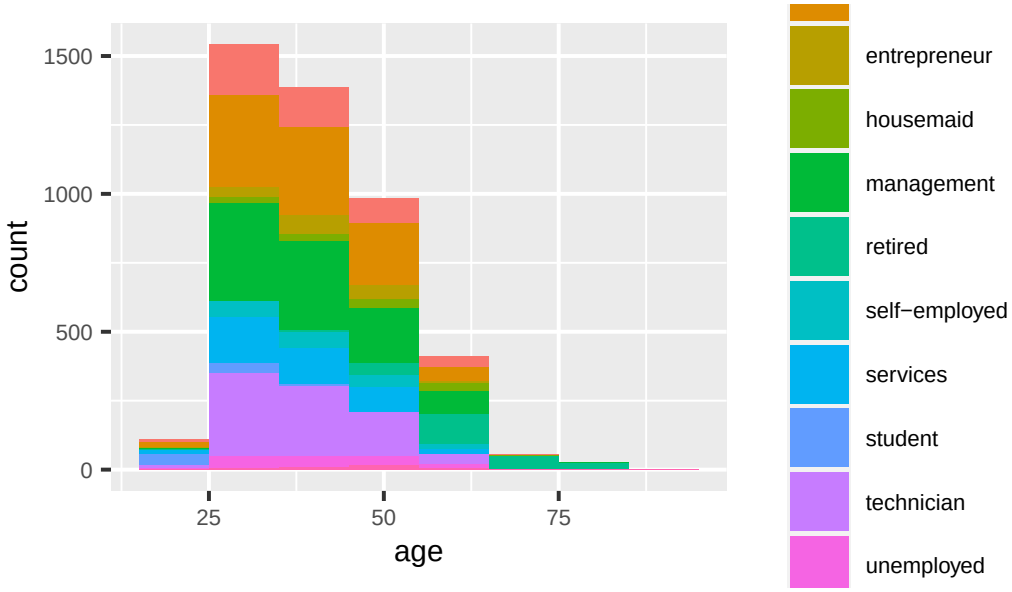
histogram: duration and job and `binwidth = 100`

```
ggplot(data = bank, mapping = aes(x = duration, fill = job)) +
  geom_histogram(binwidth = 100) + theme(text = element_text(size=8))
```



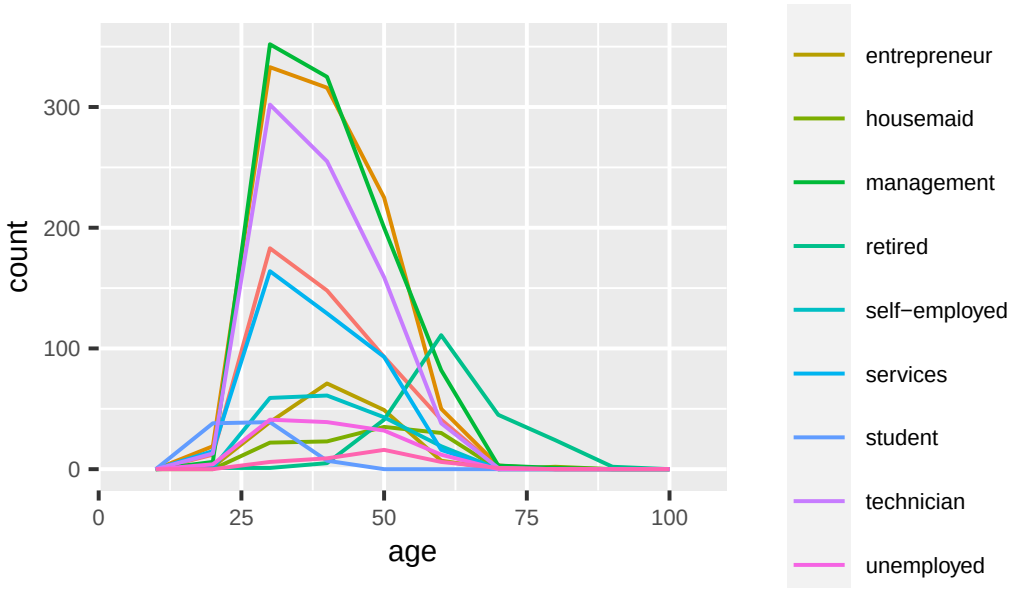
histogram: duration and job and `binwidth = 10`

```
ggplot(data = bank, mapping = aes(x = age, fill = job)) +
  geom_histogram(binwidth = 10) + theme(text = element_text(size=8))
```



histogram: age and job and colour

```
ggplot(data = bank, mapping = aes(x = age, colour = job)) +
  geom_freqpoly(binwidth = 10) + theme(text = element_text(size=8))
```

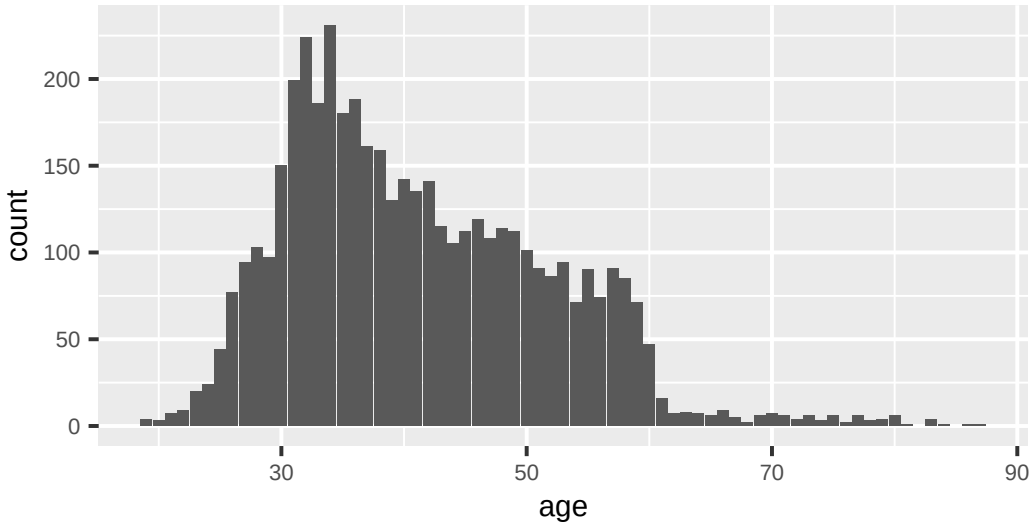


geom_bar

- bar is a statistical function: It counts.

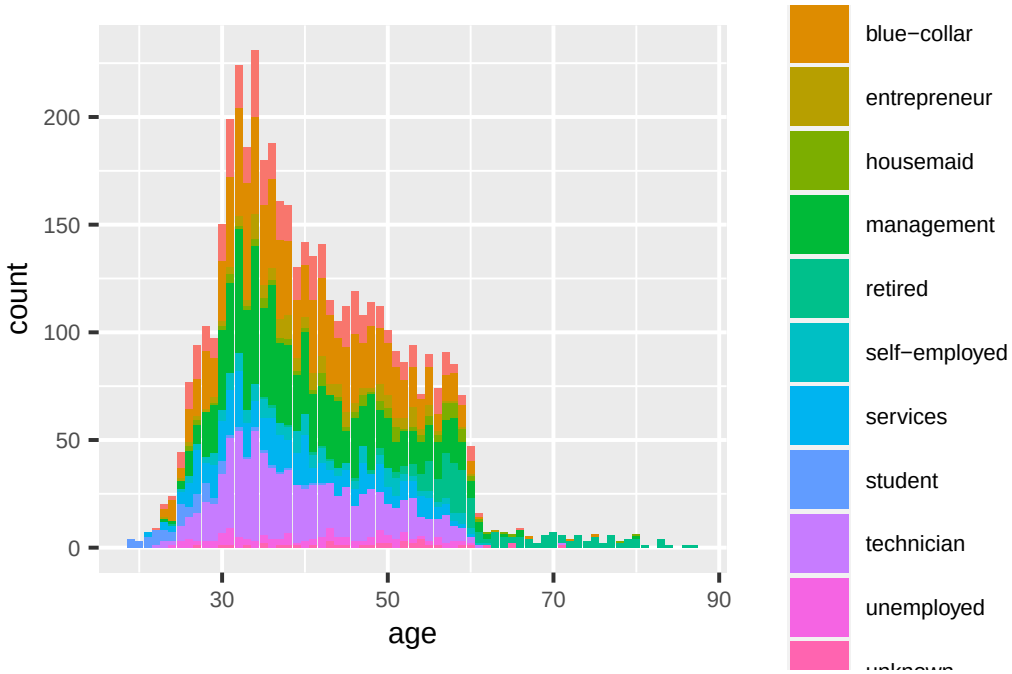
```
# First input parameter to geom_bar is mapping, so we can skip it.
ggplot(bank) + geom_bar(mapping = aes(x = age)) +
  theme(text = element_text(size=8))
```

```
# We can skip mapping
ggplot(bank) + geom_bar(aes(x = age)) +
  theme(text = element_text(size=8))
```



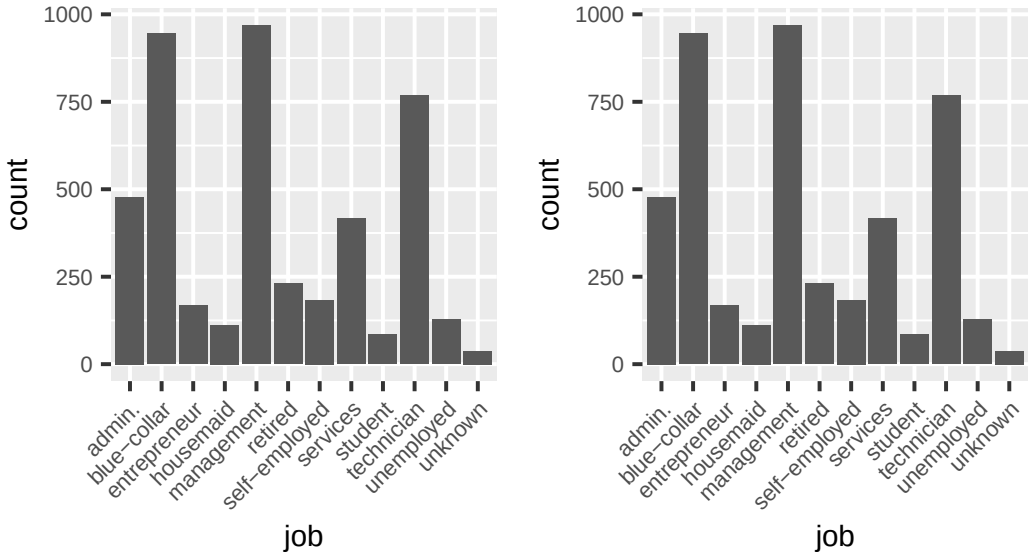
geom_bar with fill: job

```
# comparing to colour, for Bar, we better use fill
# ggplot(data = bank) + geom_bar(aes(x = age, colour = job))
ggplot(bank) + geom_bar(mapping = aes(x = age, fill = job)) +
  theme(text = element_text(size=8))
```



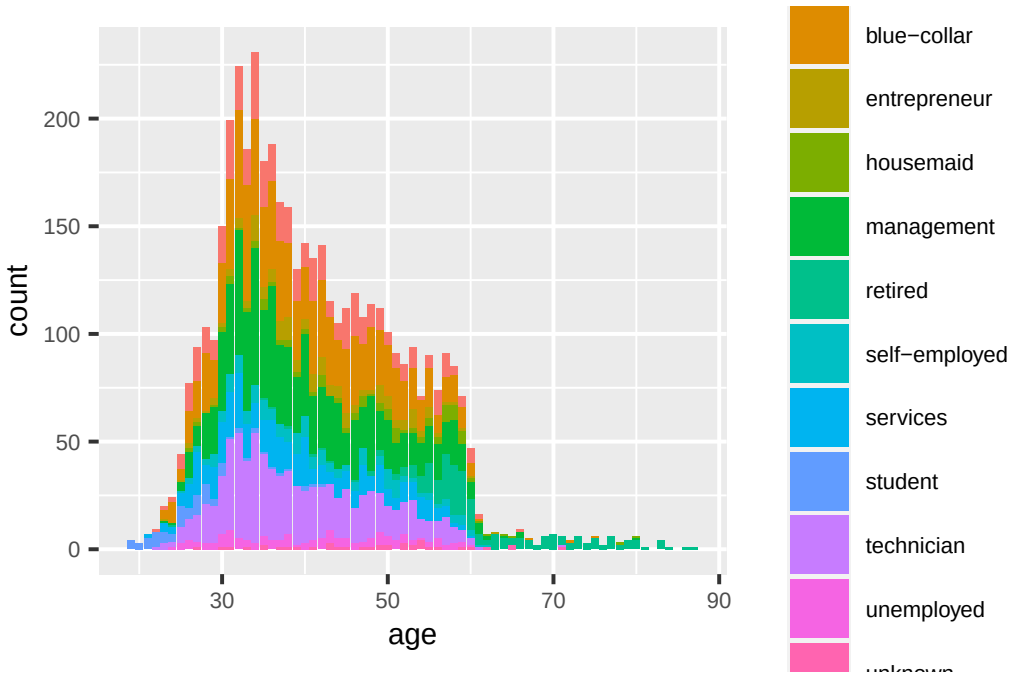
geom_bar with fill: age

```
ggplot(bank) +
  geom_bar(mapping = aes(x = job)) +
  theme(text = element_text(size=8))
# Color doesn't work, because age is a continuous variable.
ggplot(bank) +
  geom_bar(mapping = aes(x = job, fill = age)) +
  theme(text = element_text(size=8))
```



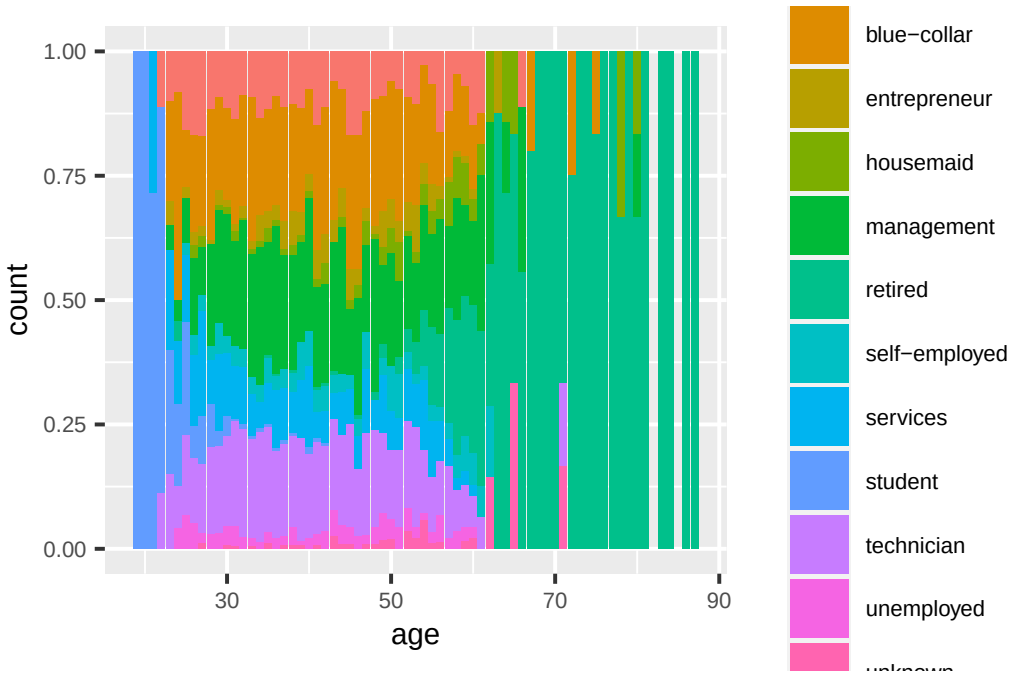
Position for bar

```
ggplot(bank) + geom_bar(mapping = aes(x = age, fill = job)) +
  theme(text = element_text(size=8))
```



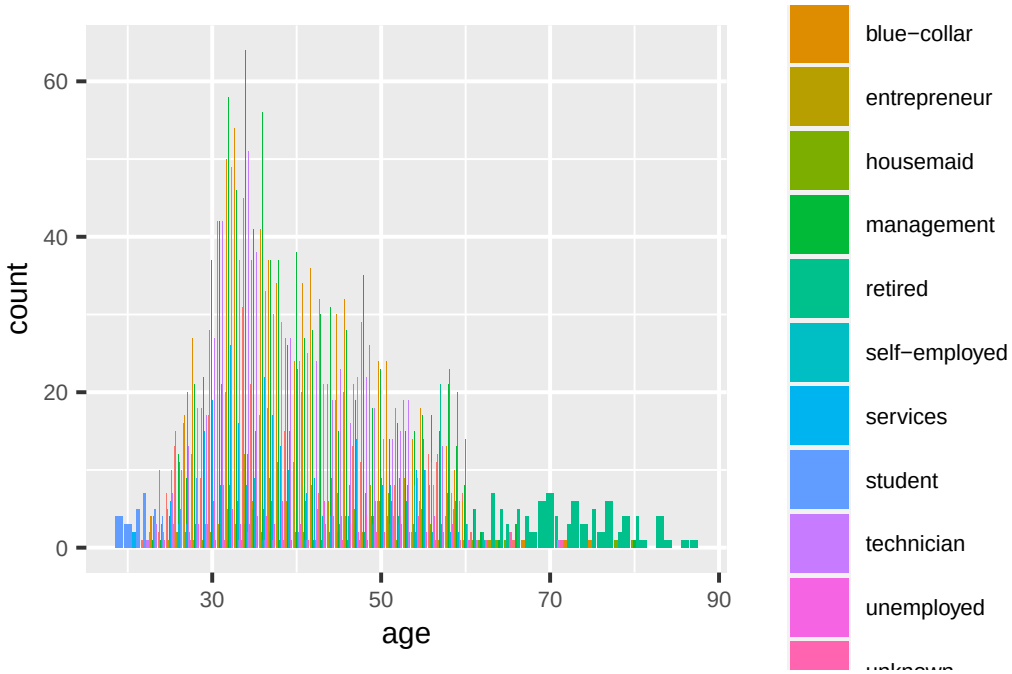
Position for bar: fill

```
# fill to 100%. good to show relative change in different allocations.
ggplot(bank) + geom_bar(mapping = aes(x = age, fill = job),
                        position = "fill") +
  theme(text = element_text(size=8))
```



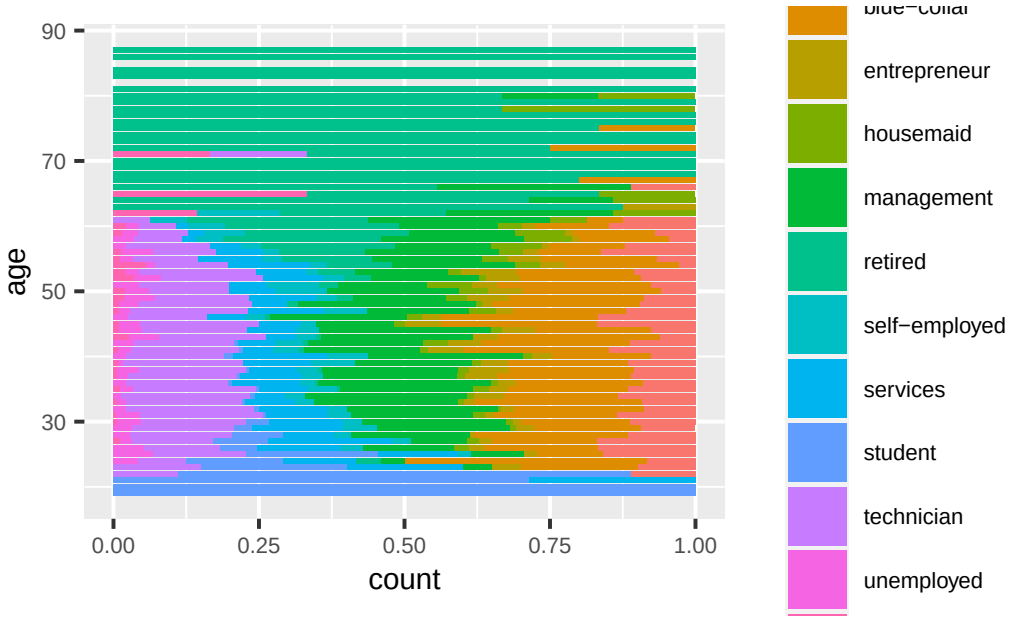
Position for bar: dodge

```
# dodge means "adaptive width of the bar".
ggplot(bank) + geom_bar(mapping = aes(x = age, fill = job),
                        position = "dodge") +
  theme(text = element_text(size=8))
```



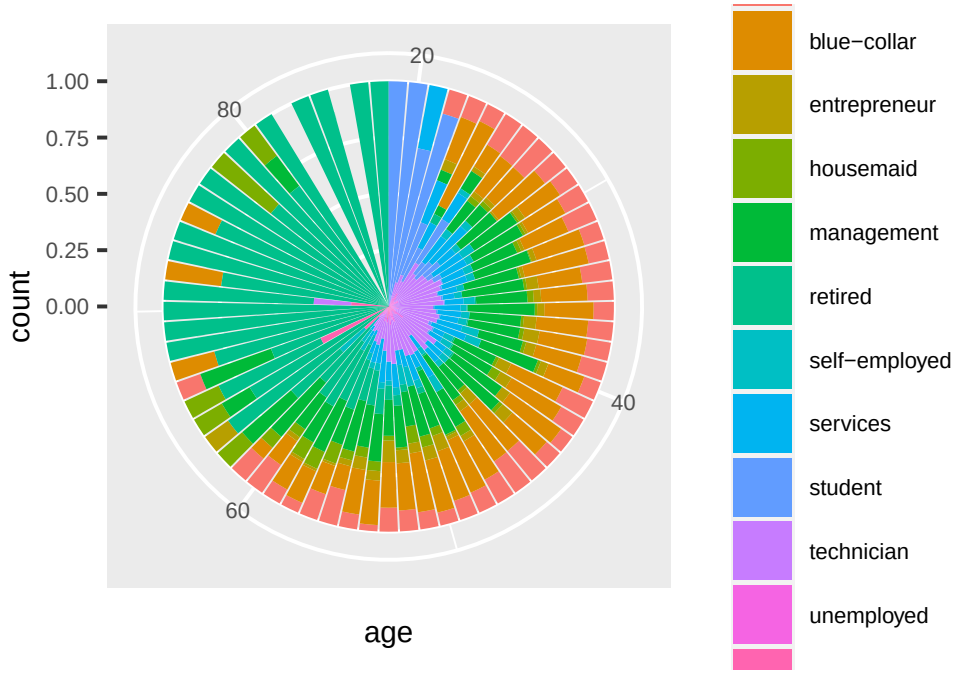
Variations: coord_flip

```
# Switch x and y axis.
# Note any adjustment on x or y axis is effective on the original name.
ggplot(bank) +
geom_bar(mapping = aes(x = age, fill = job), position = "fill") +
coord_flip() + theme(text = element_text(size=8))
```



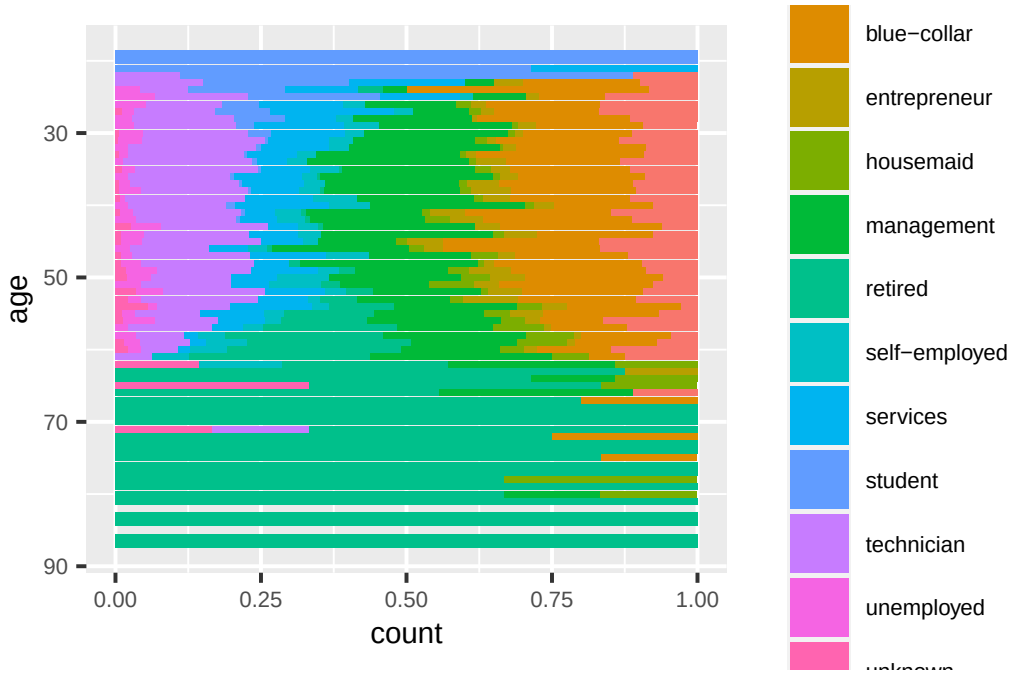
Variations: coord_polar

```
ggplot(bank) +
geom_bar(mapping = aes(x = age, fill = job), position = "fill") +
coord_polar() + theme(text = element_text(size=8))
```



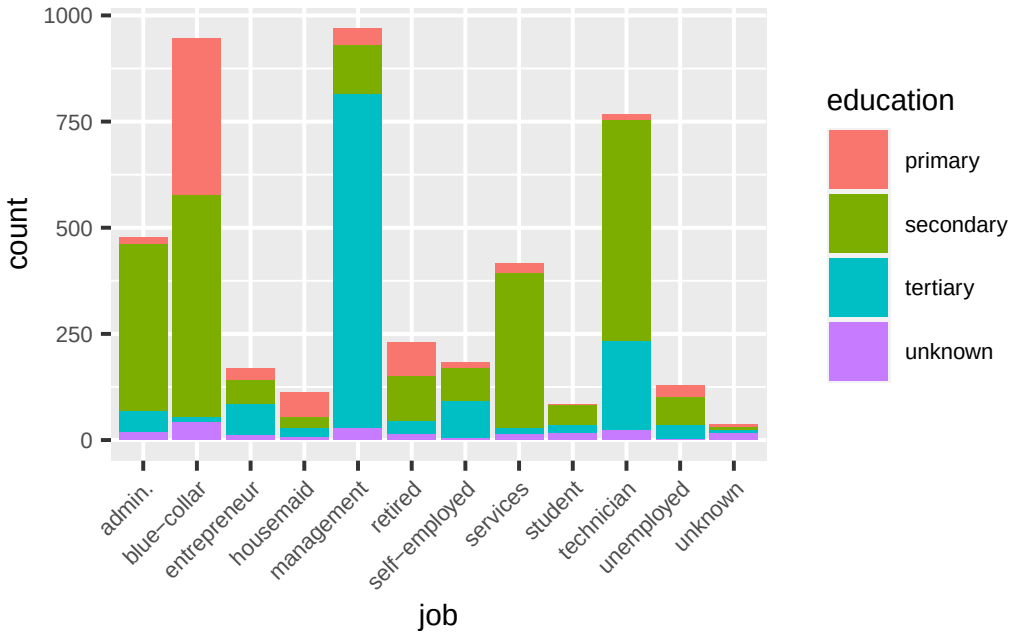
Variations: scale_x_reverse

```
# scale_x_reverse works on continous variable (numeric, date, etc.). Make it big to .
ggplot(bank) +
geom_bar(mapping = aes(x = age, fill = job), position = "fill") +
coord_flip() + scale_x_reverse() + theme(text = element_text(size=8))
```



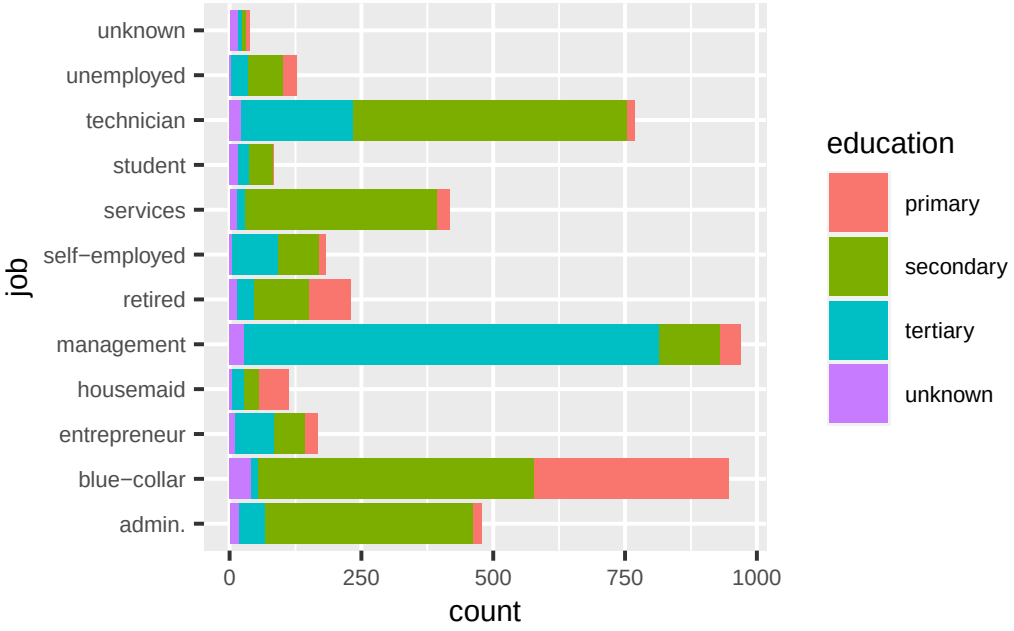
geom_bar: better serves for categorical data

```
ggplot(data = bank, mapping = aes(x = job, fill = education)) +
  geom_bar() +
  theme(text = element_text(size=8),
        axis.text.x = element_text(angle = 45, hjust = 1))
```



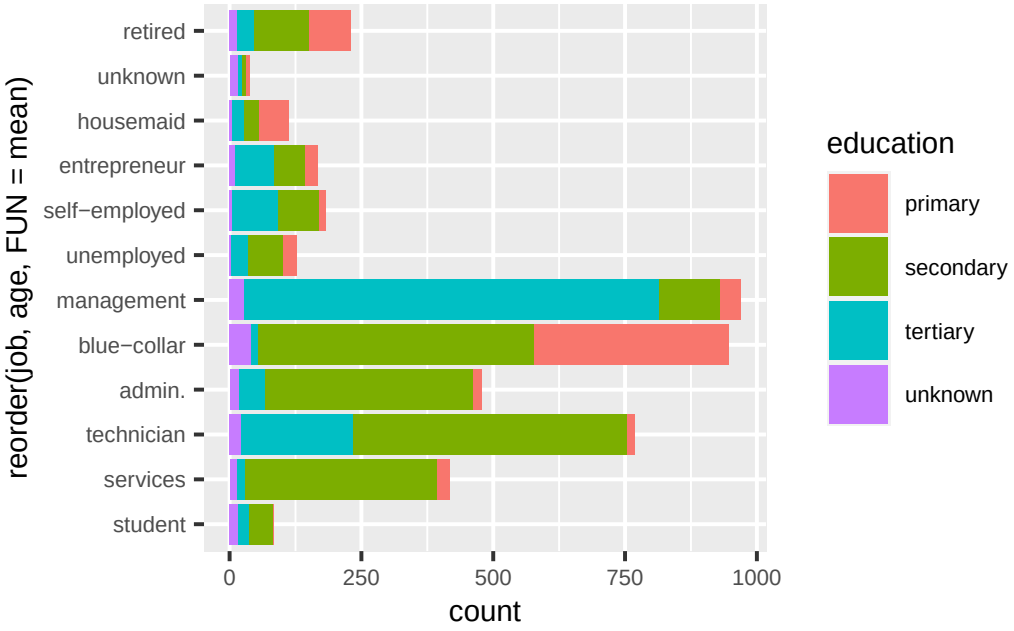
geom_bar: coord_flip

```
ggplot(data = bank, mapping = aes(x = job, fill = education)) +
  geom_bar() + coord_flip() + theme(text = element_text(size=8))
```



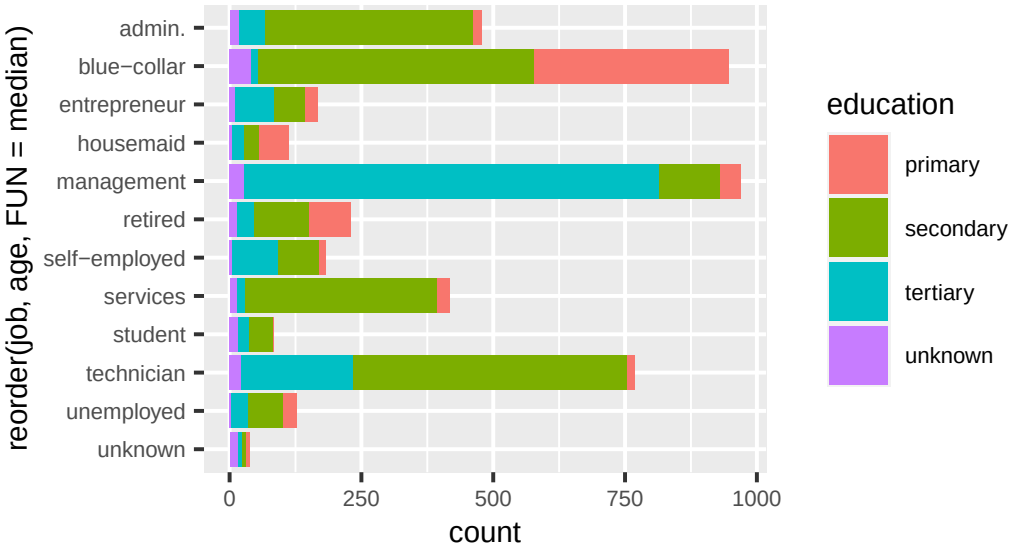
geom_bar: sort job by mean age

```
ggplot(data = bank, mapping = aes(x = reorder(job, age, FUN = mean),
       fill = education)) + geom_bar() +
  coord_flip() + theme(text = element_text(size=8))
```



geom_bar: sort job by alphabetical order

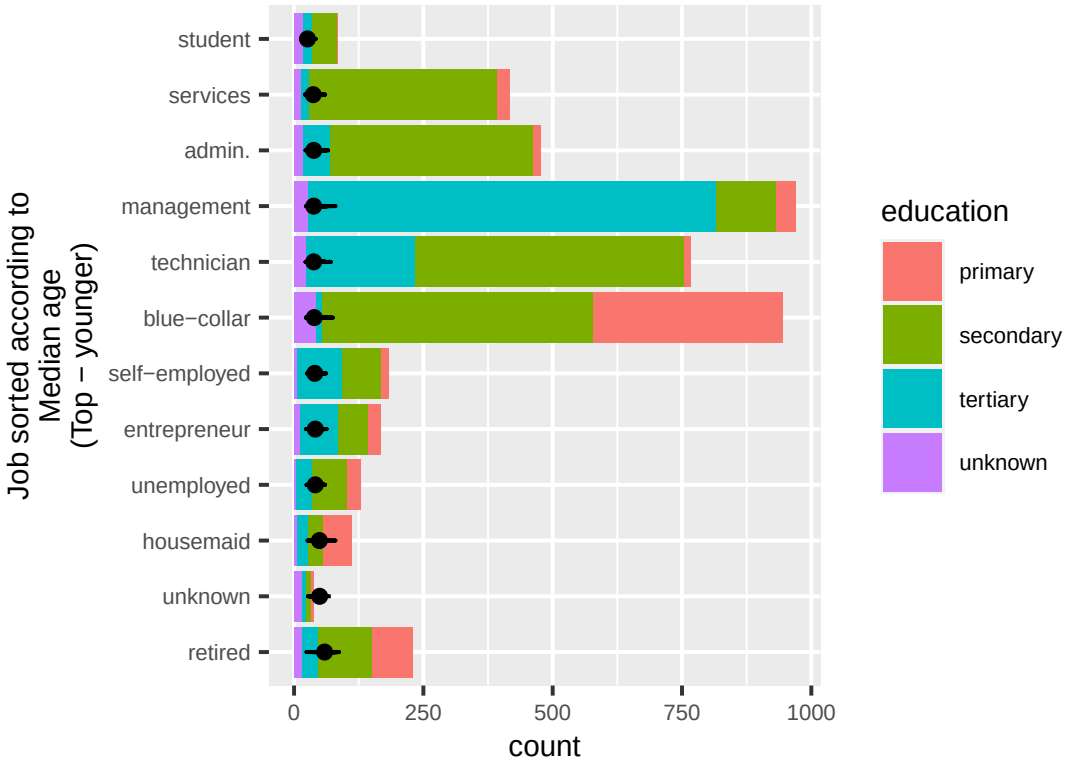
```
# If we want to order job according to alphabetical order.
# use rev(levels(factor(bank$job)))
ggplot(data = bank, mapping = aes(x = reorder(job, age, FUN = median),
       fill = education)) + geom_bar() +
  scale_x_discrete(limit = rev(levels(factor(bank$job)))) +
  coord_flip() + theme(text = element_text(size=8))
```



Bar with composite data

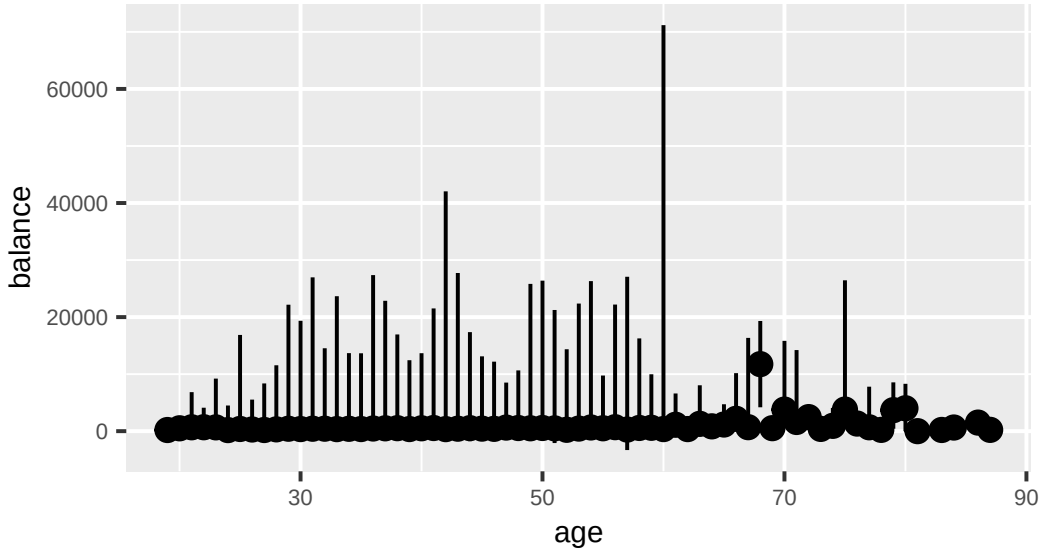
```
ggplot(data = bank, mapping = aes(x = reorder(job, age, FUN = median),
       fill = education)) +
  # layer 1
  geom_bar() +
  # If we want to sort the job acccording to median age
  scale_x_discrete(limit =
    rev(levels(reorder(bank$job, bank$age, FUN = median)))) +
  # And also add age range and median age.
  geom_line(aes(x = job, y = age)) +
  geom_point(data = group_by(bank, job) %>%
               summarize(age = median(age)) %>% ungroup,
             aes(x = job, y = age), inherit.aes = FALSE) +
  xlab("Job sorted according to\nMedian age\n(Top - younger)") +
  coord_flip() + theme(text = element_text(size=8))
```

Bar with composite data: plot



Data with statistical

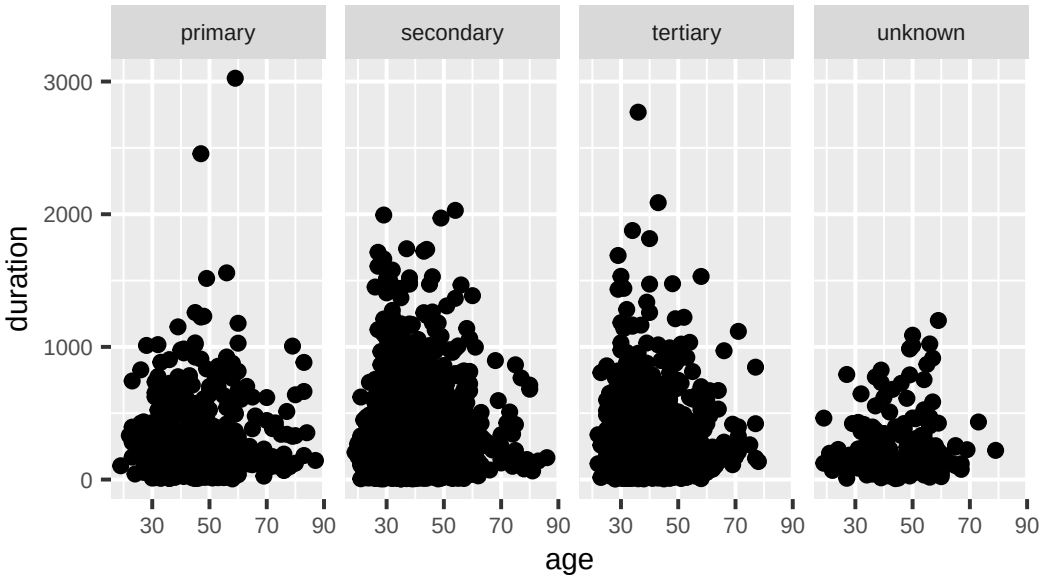
```
suppressWarnings({
  ggplot(data = bank) +
  stat_summary(
    mapping = aes(x = age, y = balance),
    fun.ymin = min,
    fun.ymax = max,
    fun.y = median
  ) + theme(text = element_text(size=8))
})
```



Facets

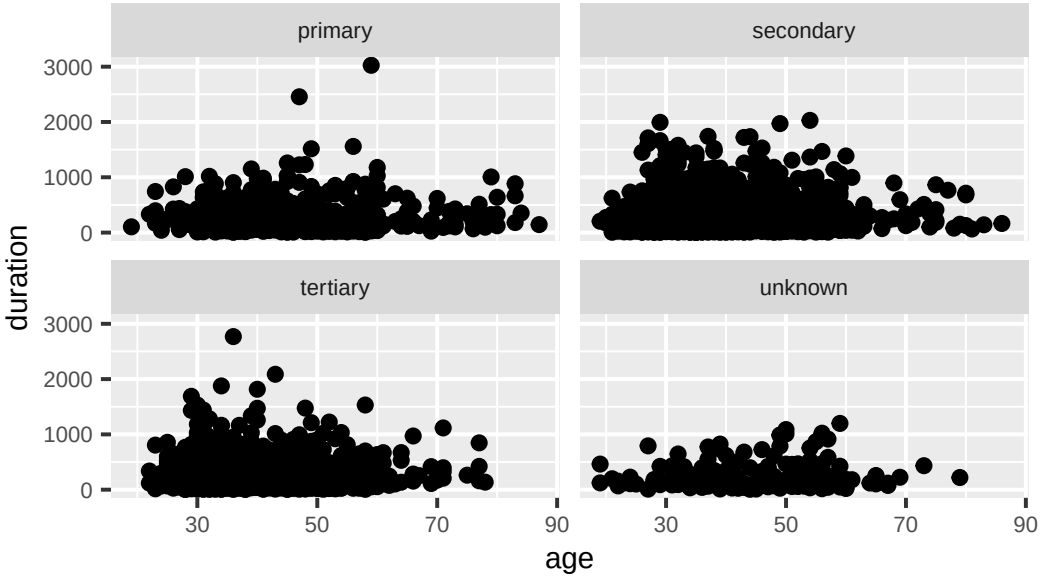
- Create invidual figures.
- `facet_grid`: basic
- `facet_wrap`: you can control number of rows and cols

```
ggplot(data = bank) +
  geom_point(mapping = aes(x = age, y = duration)) +
  facet_grid( ~ education) + theme(text = element_text(size=8))
```



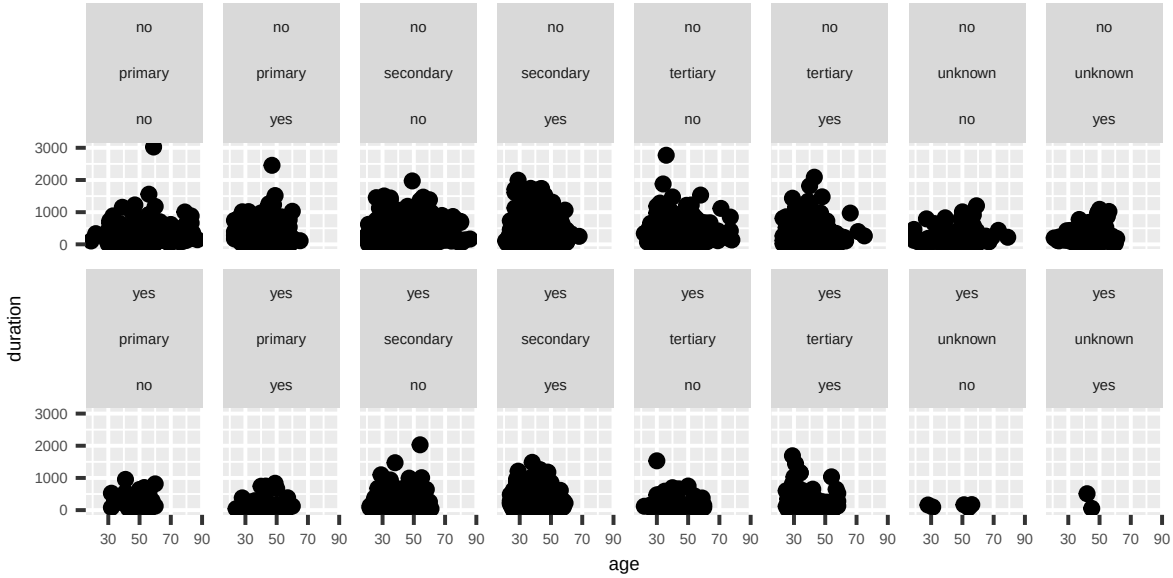
Facets - `facet_wrap`

```
ggplot(data = bank) +
  geom_point(mapping = aes(x = age, y = duration)) +
  facet_wrap(~ education, nrow = 2) +
  theme(text = element_text(size=8))
```



Facets - `facet_wrap` multi-dimension

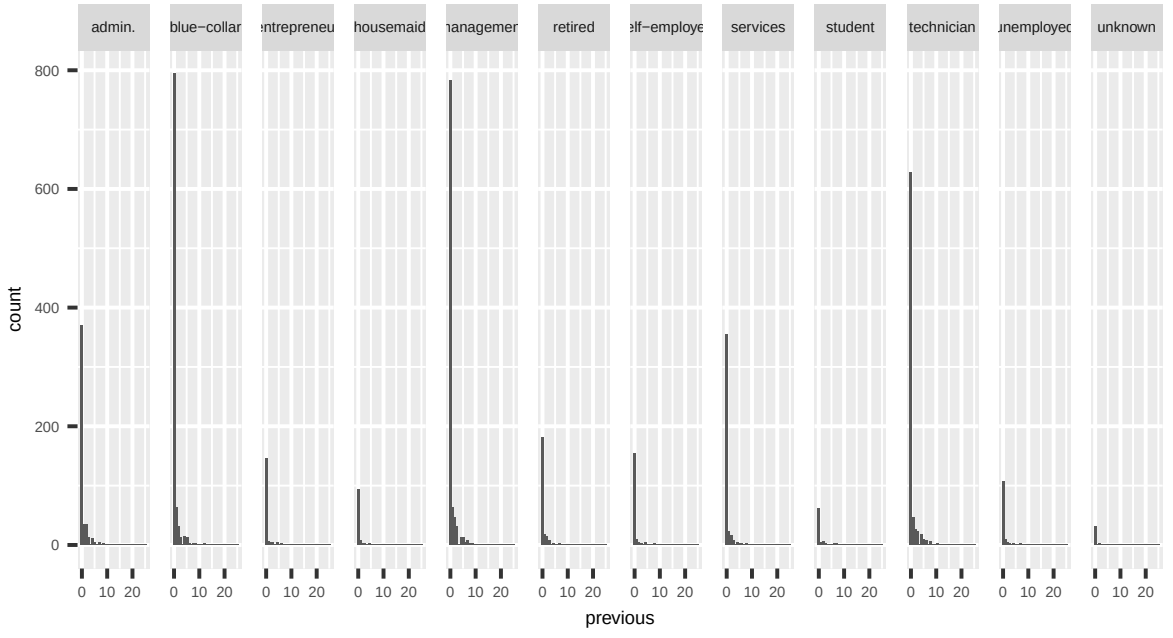
```
ggplot(data = bank) +
  geom_point(mapping = aes(x = age, y = duration)) +
  facet_wrap(loan ~ education ~ housing, nrow = 2) +
  theme(text = element_text(size=5))
```




```
  # or we can use, facet_grid(loan ~ education ~ housing)
```


With facets or without facets? Case 1

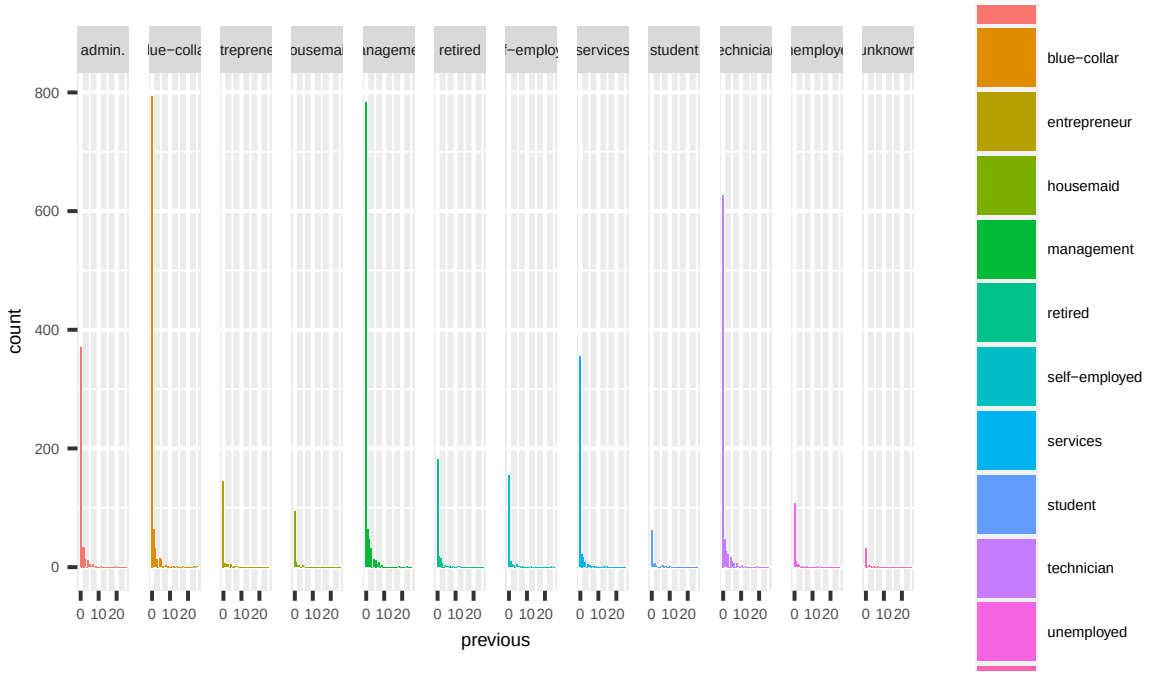
```
ggplot(bank, aes(previous)) + geom_histogram() + facet_grid(. ~ job) +
  theme(text = element_text(size=5))
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



With facets or without facets? Case 1

- facets with color

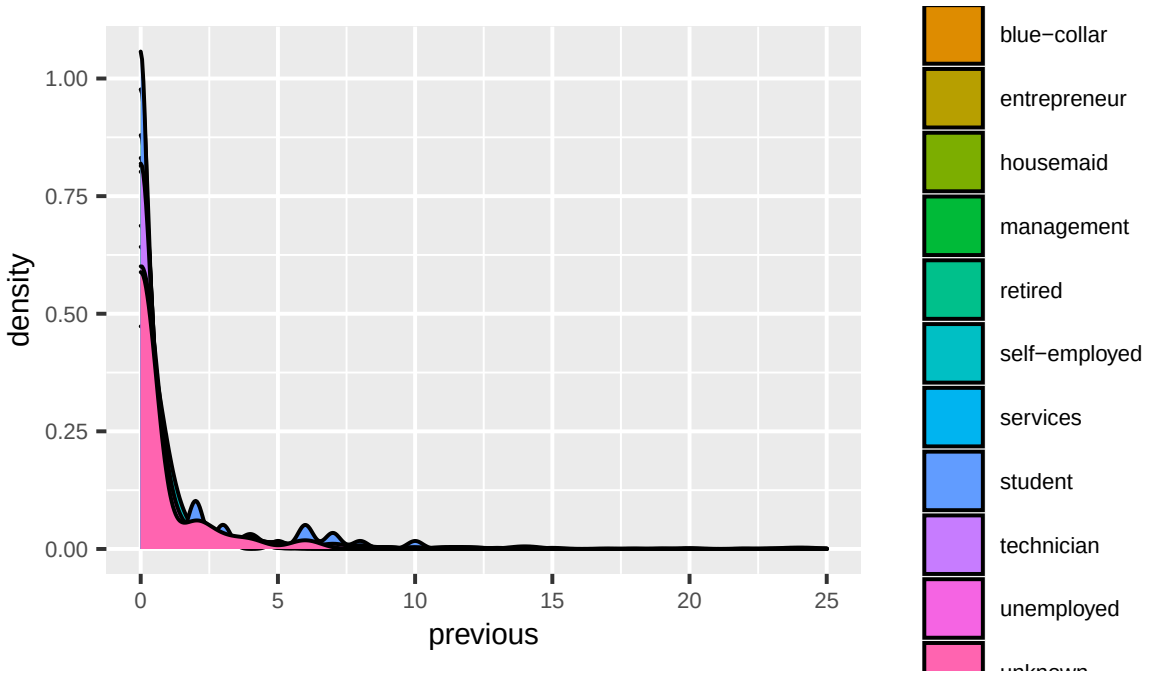
```
ggplot(bank, aes(previous)) + geom_histogram(aes(fill = job)) +
  facet_grid(. ~ job) + theme(text = element_text(size=5))
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



With facets or without facets?

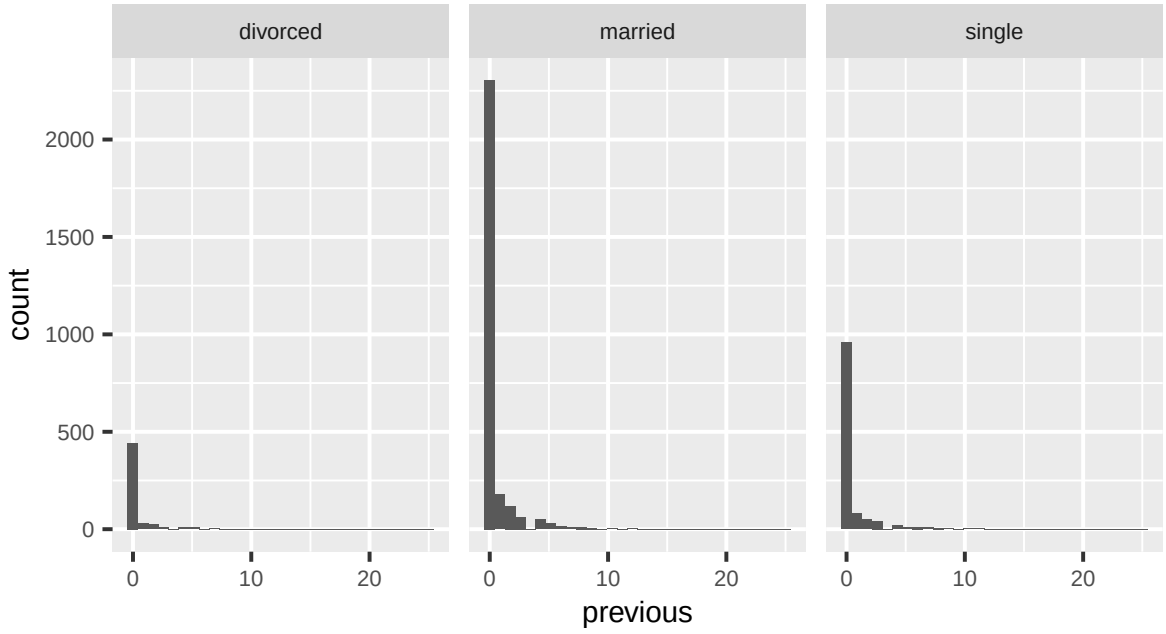
- Use density/color on one figure

```
ggplot(bank, aes(previous)) + geom_density(aes(fill = job)) +
  theme(text = element_text(size=8))
```



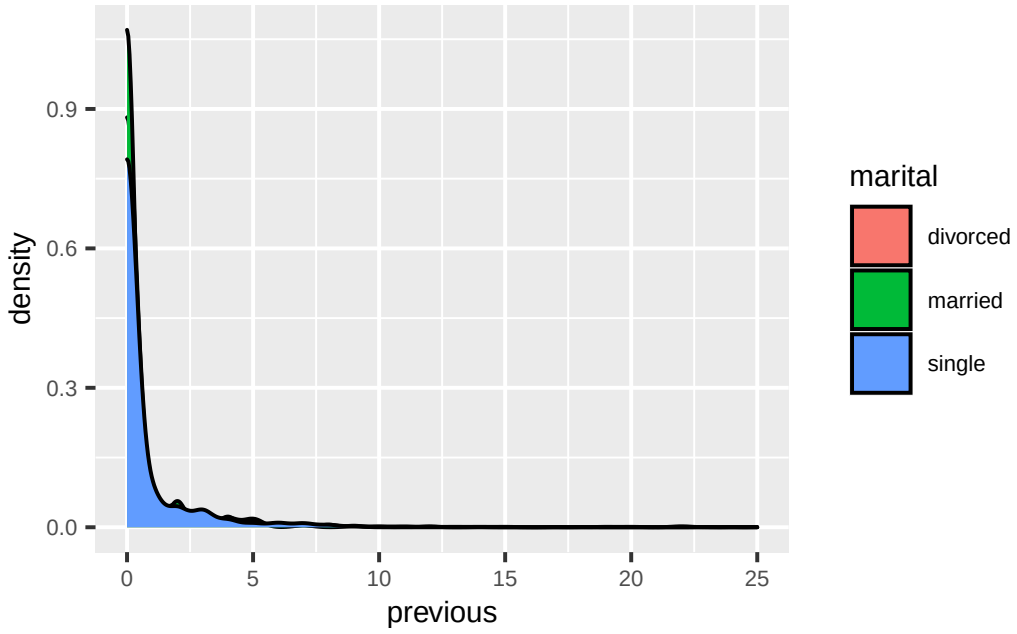
With facets or without facets: Case 2

```
ggplot(bank, aes(previous)) + geom_histogram() +
  facet_grid(. ~ marital) + theme(text = element_text(size=8))
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



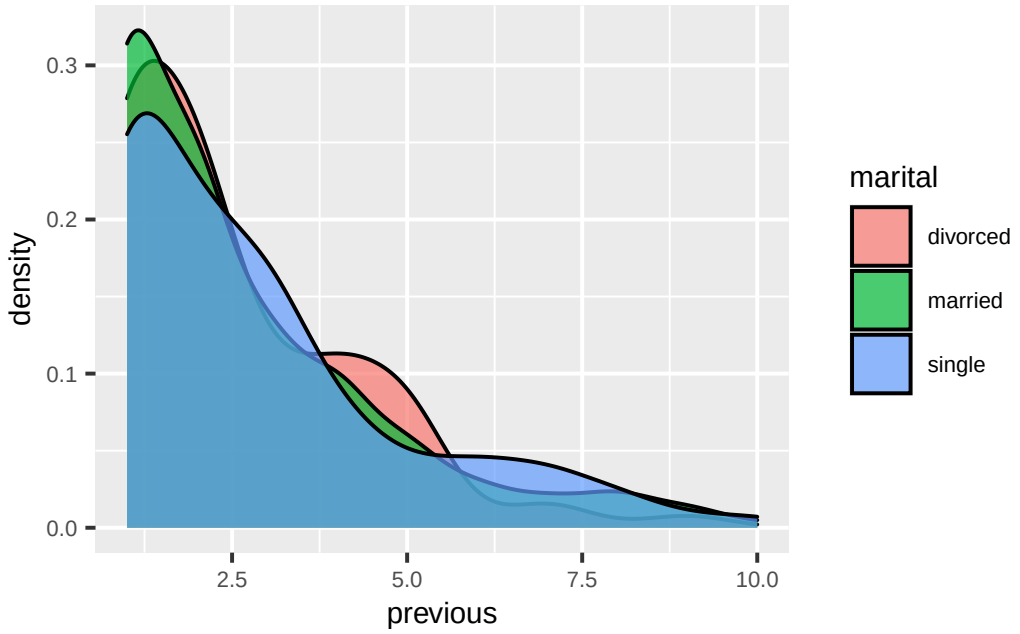
With facets or without facets: `geom_density` and `fill`

```
ggplot(bank, aes(previous)) + geom_density(aes(fill = marital)) +
  theme(text = element_text(size=8))
```



With facets or without facets: `xlim` to zoom in

```
ggplot(bank, aes(previous)) +
  geom_density(aes(fill = marital), alpha = 0.7) +
  xlim(1, 10) + theme(text = element_text(size=8))
## Warning: Removed 3725 rows containing non-finite values (stat_density).
```



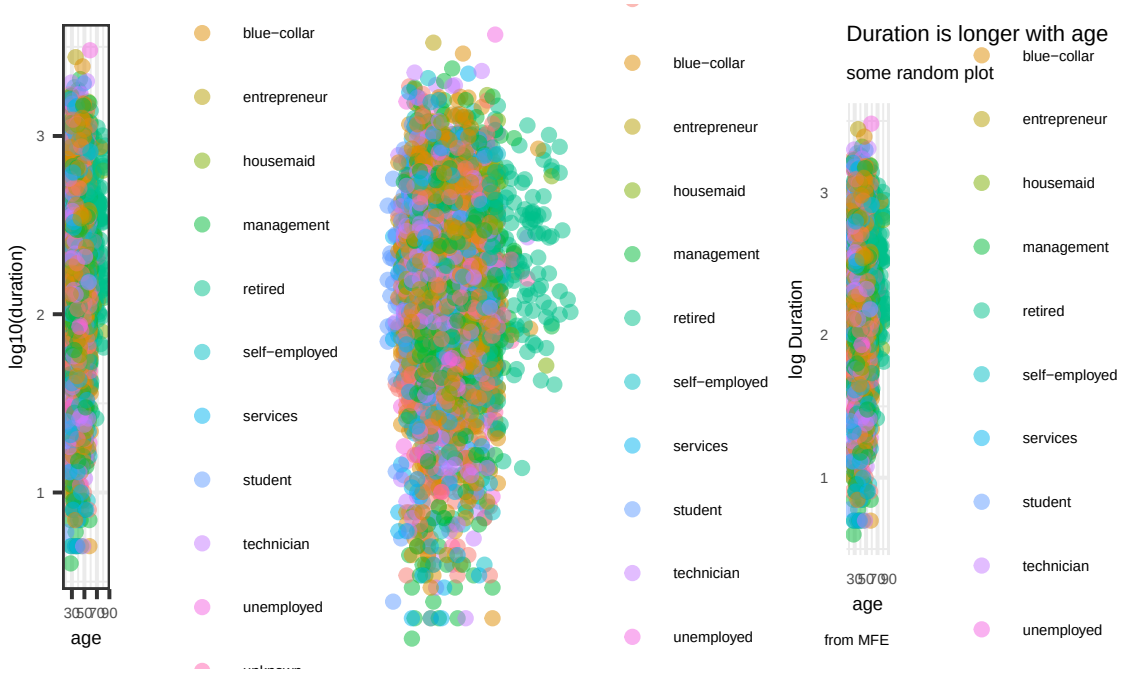
Add theme

The default theme is theme_gray()

```
g <- ggplot(bank, aes(x = age, y = log10(duration)))
g + geom_point(aes(color = job), size = 4, alpha = 1/2) + theme_bw()
g + geom_point(aes(color = job), size = 4, alpha = 1/2) + theme_void()

g + geom_point(aes(color = job), size = 4, alpha = 1/2) + theme_minimal() +
    labs(title = "Duration is longer with age",
        subtitle = "some random plot",
        caption = "from MFE") +
    labs(x = "age", y = expression("log " * Duration))
```

Add theme: result



ggthemes

- package `ggthemes` provides many other themes.

```
library(ggthemes)
## [1] "theme_base" "theme_calc"
## [3] "theme_economist" "theme_economist_white"
## [5] "theme_excel" "theme_few"
## [7] "theme_fivethirtyeight" "theme_foundation"
## [9] "theme_gdocs" "theme_hc"
## [11] "theme_igray" "theme_map"
## [13] "theme_pander" "theme_par"
## [15] "theme_solarized" "theme_solarized_2"
## [17] "theme_solid" "theme_stata"
## [19] "theme_tufte" "theme_wsj"
```

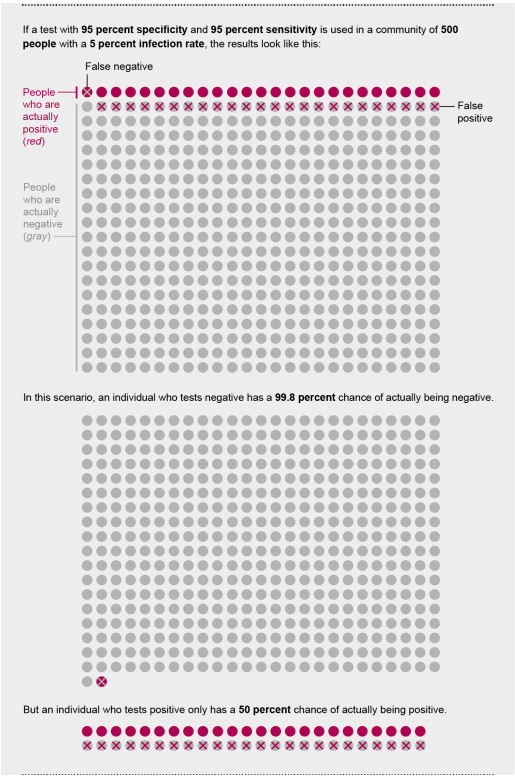
Take-home: ggplot summary

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


Assignment

- In an R Markdown document, produce 6 data insights.
  - Each with a figure and a data story.
  - You can re-use up-to-3 existing examples.
- "Coronavirus Antibody Tests Have a Mathematical Pitfall", title "False Positive Alarm" in Scientific American 323, 1, 12-13 (July 2020).
  - https://www.scientificamerican.com/article/coronavirus-antibody-tests-have-a-mathematical-pitfall/
  - Create a Shiny App that reproduces the infographic with input of infection rate.
  - Test specificity and sensitivity are fixed at 95%.

Assignment - 2



Assignment - 2

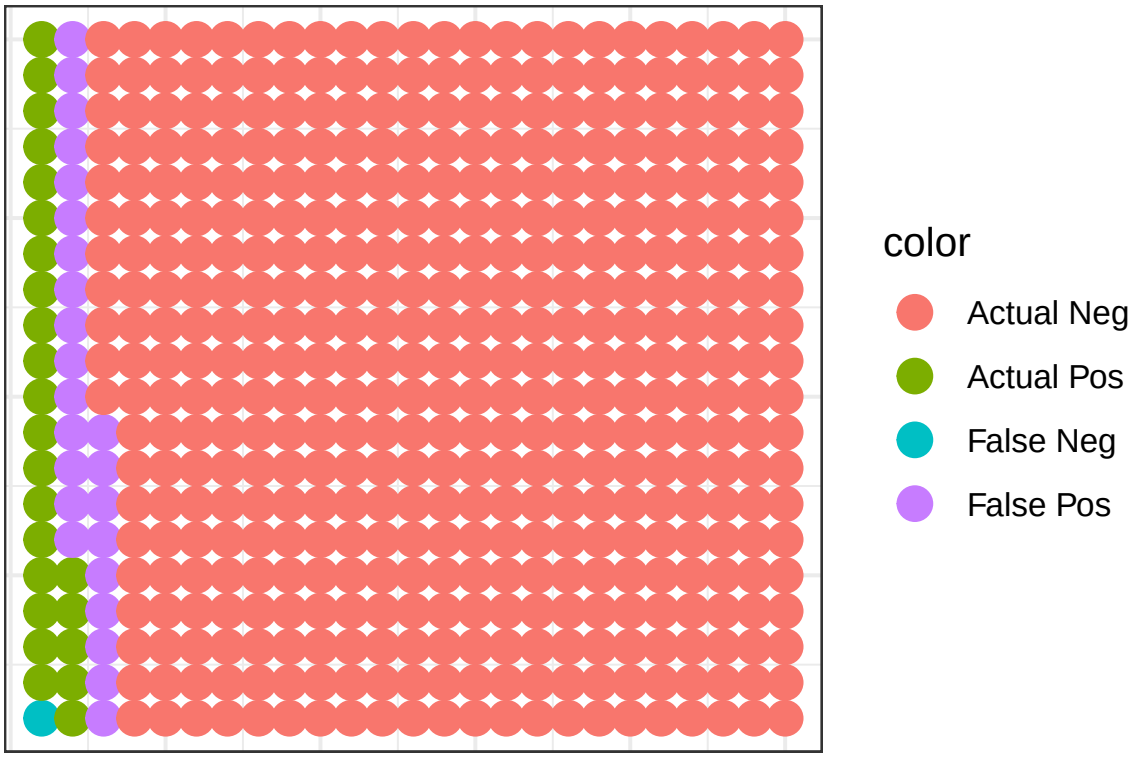
Below code to help start with.

```
df_sensi <- full_join(
  tibble(x = 1:25, color = 'Actual Neg'),
  tibble(y = 1:20, color = 'Actual Neg'),
  by = 'color')

# At 5% infection rate,
# Positive 500 * 5% = 25 = Actual Pos (24 at 95%) + False Neg (1 at 5%)
# Negative 500 * 95% = 475 = Actual Neg (451 at 95%) + False Pos (24 at 5%)
df_sensi['color'] <- c(rep('False Neg', 1),
                       rep('Actual Pos', 24),
                       rep('False Pos', 24),
                       rep('Actual Neg', 500 - 1 - 24 - 24))

ggplot(df_sensi) +
  geom_point(aes(x, y,colour = color),
             size =  4, shape="circle") +
  theme_bw() +
  theme(axis.title.x=element_blank(), axis.title.y=element_blank(),
        axis.line=element_blank(),axis.text.x=element_blank(),
        axis.text.y=element_blank(),axis.ticks=element_blank())
```

Assginment - 2



Assignment - 3 / 1

- Pick four stocks/ETFs + SPY (S&P 500 ETF) in US market. You may get the list of symbols here https://en.wikipedia.org/wiki/List_of_S%26P_500_companies
  - Download recent 100 day's price. E.g. `df <- av_get("MSFT", av_fun = "TIME_SERIES_DAILY_ADJUSTED")`
  - Save them into `/data` directory under `/Assignment 4`.
  - With $1mio cash, invest with equal-weighted (long only) in the four stocks/ETF on the 1st day with adjusted_close.
  - Take cash reserve of about 10% (about 90% are investiable). Make sure invest in integer number of shares.
  - We only use adjusted_close for buying/selling price and valuation.

Assignment - 3 / 2

- Suppose you are to report this investment to client. Do below in a R Markdown document
  - Load the data.
  - Decide the allocation n_i per stock. Calculate daily valuation of the portfolio, $Value = \Sigma n_i * price_i$, return of the portfolio, $R_p = \frac{Value_{d+1}}{Value_d} - 1$
  - Calculate the Sharpe ratio for this portfolio and S&P: $Sharpe\ Ratio = \frac{R_p(mean) - R_f}{\sigma_p}$ with $R_f = 0.01/250$, $\sigma_p = Stdev(R_p)$
  - Plot a histogram of daily return.
  - Plot total valuation, and relativity return for your investment portfolio and S&P.
  - Plot relative valuation for the different allocation (stocks and cash) (Hint: bar chart)