

# talk10 练习与作业

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### 0.1 练习和作业说明

将相关代码填写入以 “{r}” 标志的代码框中，运行并看到正确的结果；

完成后，用工具栏里的”Knit” 按键生成 PDF 文档；

将 PDF 文档改为：姓名-学号-talk10 作业.pdf，并提交到老师指定的平台/钉群。

### 0.2 Talk10 内容回顾

- data summarisation functions (vector data)
  - median, mean, sd, quantile, summary
- 图形化的 data summarisation (two-D data/ tibble/ table)
  - dot plot

- smooth
  - linear regression
  - correlation & variance explained
  - grouping & bar/ box/ plots
- statistics
  - parametric tests
    - \* t-test
    - \* one way ANNOVA
    - \* two way ANNOVA
    - \* linear regression
    - \* model / prediction / coefficients
  - non-parametric comparison

### 0.3 练习与作业：用户验证

请运行以下命令，验证你的用户名。

如你当前用户名不能体现你的真实姓名，请改为拼音后再运行本作业！

```
Sys.info()[["user"]]
```

```
## [1] "lucas"
```

```
Sys.getenv("HOME")
```

```
## [1] "/Users/lucas"
```

### 0.4 练习与作业 1：数据查看

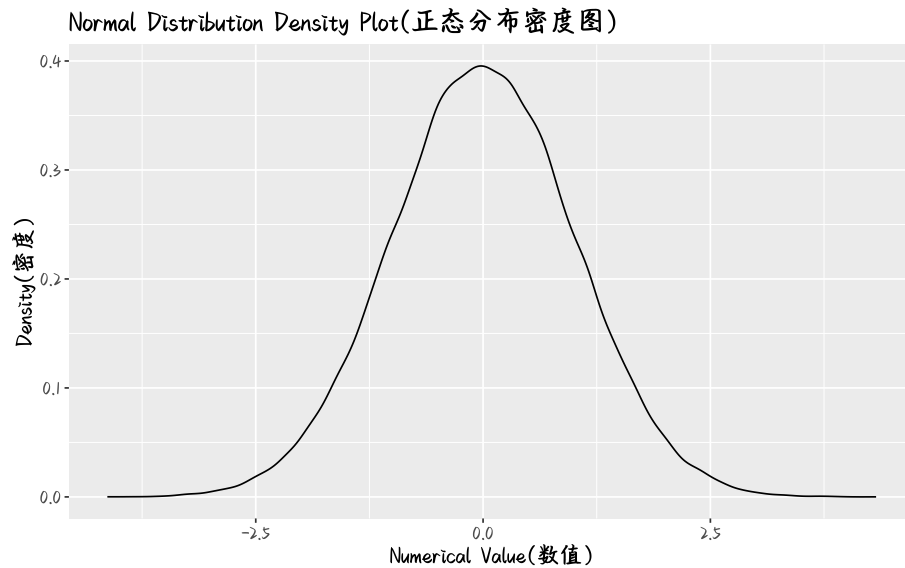
- 
- 正态分布

1. 随机生成一个数字 (numeric) 组成的 vector, 长度为 10 万, 其值符合正态分布;
2. 用 ggplot2 的 density plot 画出其分布情况;
3. 检查  $\text{mean} \pm 1 * \text{sd}$ ,  $\text{mean} \pm 2 * \text{sd}$  和  $\text{mean} \pm 3 * \text{sd}$  范围内的取值占总值数量的百分比。

```
## 代码写这里, 并运行;
library(ggplot2)

# Setting random seeds to ensure reproducibility
set.seed(123)
data = rnorm(100000)
df = data.frame(value = data)

# Creating density maps with ggplot2
ggplot(df, aes(x = data)) +
  geom_density() +
  # Prevent the GBK character to show as block
  theme(
    text=element_text(
      family="RLQDMSWR",
      size=14)) +
  labs(
    title = "Normal Distribution Density Plot(正态分布密度图)",
    x = "Numerical Value(数值)",
    y = "Density(密度)"
  )
```



```
# Calculate the percentage of the total number
# of values taken in different ranges:
mean_value = mean(data)
sd_value = sd(data)

# Calculate the percentage in the range mean +/- 1 * sd
within_1_sd =
  sum(data >= mean_value - sd_value &
    data <= mean_value + sd_value) / length(data)

# Calculate the percentage in the range mean +/- 2 * sd
within_2_sd =
  sum(data >= mean_value - 2 * sd_value &
    data <= mean_value + 2 * sd_value) / length(data)

# Calculate the percentage in the range mean +/- 3 * sd
within_3_sd =
  sum(data >= mean_value - 3 * sd_value &
    data <= mean_value + 3 * sd_value) / length(data)
```

```
# Convert results to percentages  
within_1_sd * 100
```

```
## [1] 68.149
```

```
within_2_sd * 100
```

```
## [1] 95.463
```

```
within_3_sd * 100
```

```
## [1] 99.735
```

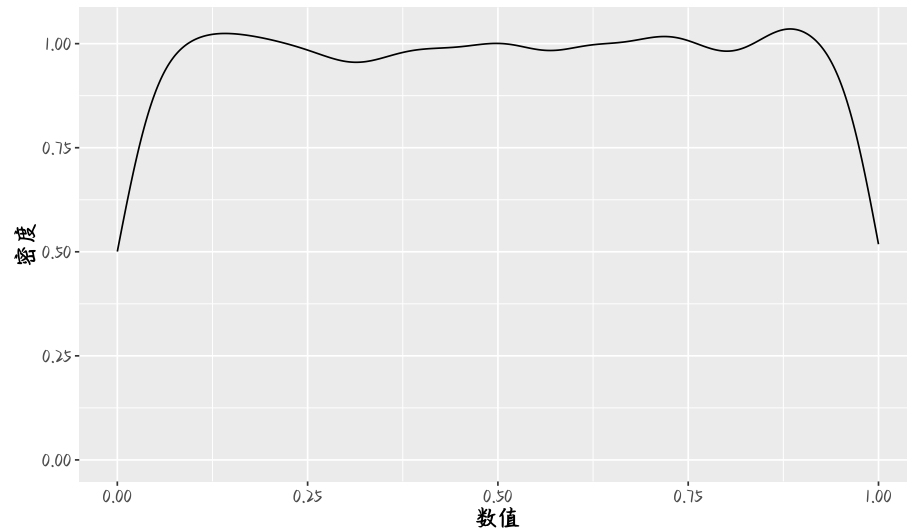
- 
- 用函数生成符合以下分布的数值，并做图：

另外，在英文名后给出对应的中文名：

- Uniform Distribution
- Normal Distribution
- Binomial Distribution
- Poisson Distribution
- Exponential Distribution
- Gamma Distribution

```
## 代码写这里，并运行；  
# Task 01: Uniform Distribution  
# Generate uniformly distributed random values  
uniform_data =  
  runif(10000,  
        min = 0,  
        max = 1)  
  
# Creating Density Maps  
ggplot(  
  data.frame(  
    x = uniform_data),  
  aes(x)) +  
  geom_density() +  
  # Prevent the GBK character to show as block  
  theme(  
    text=element_text(  
      family="RLQDMSWR",  
      size=14)) +  
  labs(  
    title = "Fig. 01: 均匀分布 (Uniform Distribution)",  
    x = " 数值",  
    y = " 密度")
```

Fig. 01: 均匀分布 (Uniform Distribution)



```
# Task 02: Normal Distribution
# Setting random seeds to ensure reproducibility
set.seed(123)

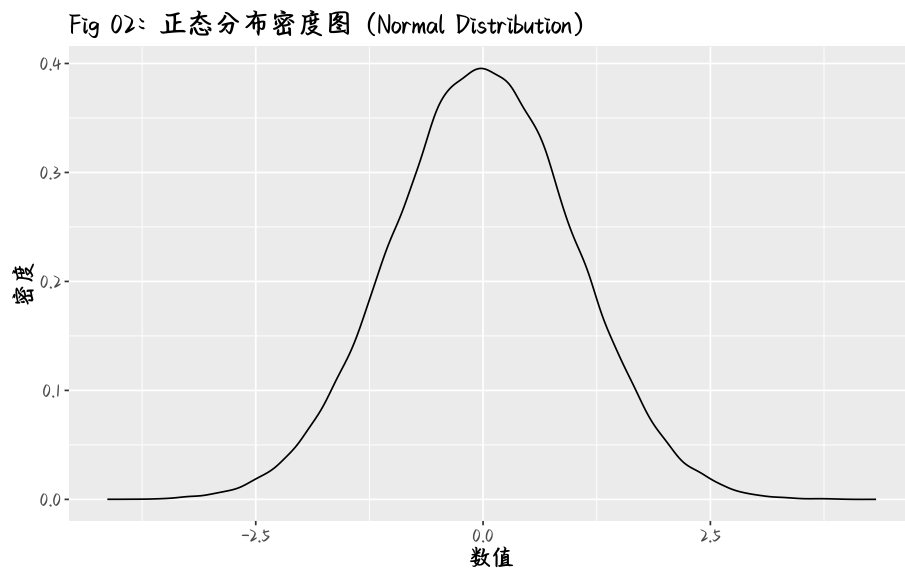
# Generate normally distributed random values
normal_data =
  rnorm(100000)

# Creating data.frame
normal_df =
  data.frame(value = normal_data)

# Creating Density Plots with ggplot2
library(ggplot2)

ggplot(normal_df,
        aes(x = value)) +
  geom_density() +
  labs(
```

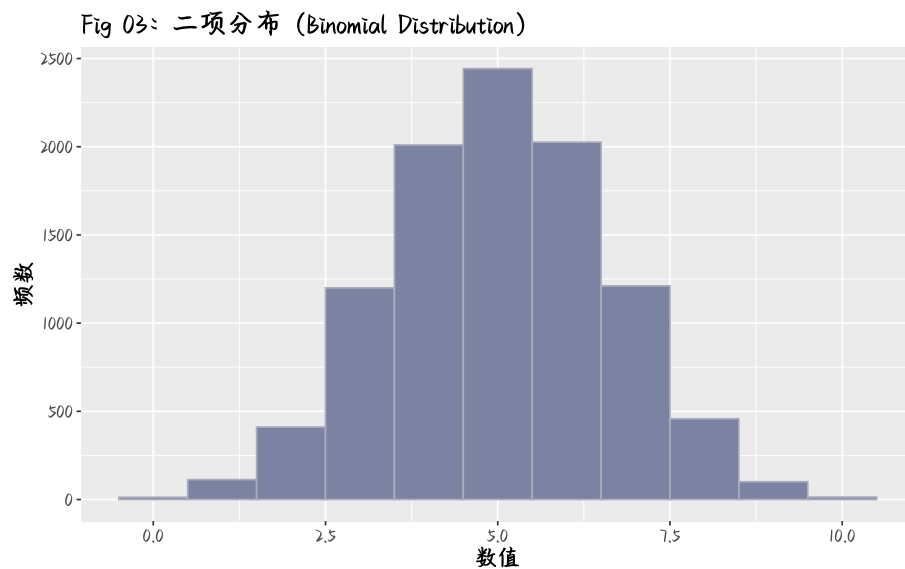
```
title = "Fig 02: 正态分布密度图 (Normal Distribution)",  
x = " 数值",  
y = " 密度") +  
# Prevent the GBK character to show as block  
theme(  
  text = element_text(  
    family = "RLQDMSWR",  
    size = 14))
```



```
# Task 03: Binomial Distribution  
# Generate random values for binomial distribution  
binomial_data =  
  rbinom(10000, size = 10, prob = 0.5)  
  
# Creating Histograms  
ggplot(  
  data.frame(  
    x = binomial_data),  
  aes(x)) +
```

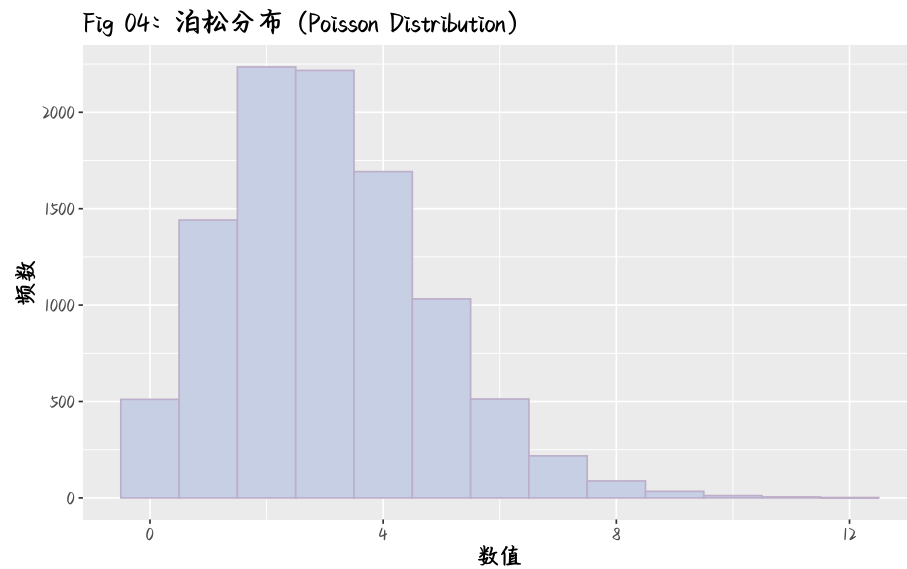


```
geom_histogram(  
  binwidth = 1,  
  fill = "#7C82A2",  
  color = "#ABADBC") +  
labs(  
  title = "Fig 03: 二项分布 (Binomial Distribution)",  
  x = " 数值",  
  y = " 频数") +  
# Prevent the GBK character to show as block  
theme(  
  text = element_text(  
    family = "RLQDMSWR",  
    size = 14))
```



```
# Task 04: Poisson Distribution  
# Generate random values for poisson distribution  
poisson_data =  
  rpois(10000, lambda = 3)
```

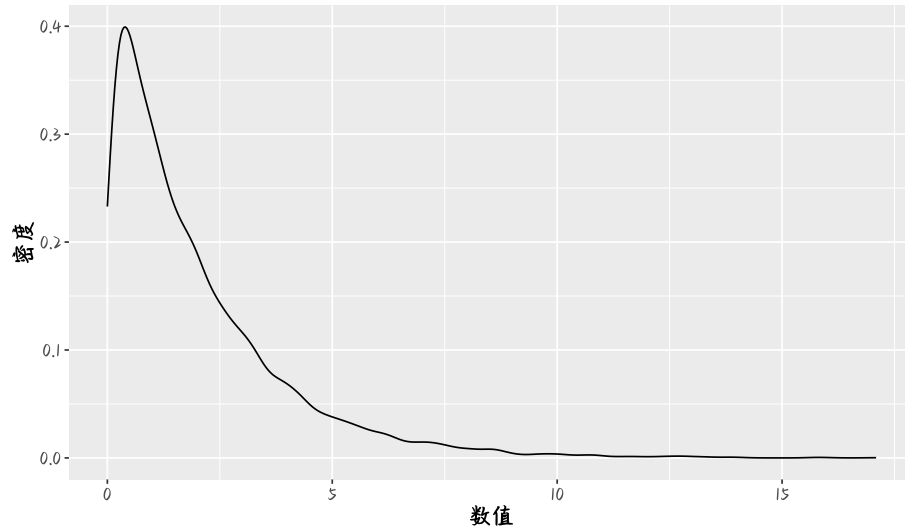
```
# Creating Histograms
ggplot(
  data.frame(
    x = poisson_data),
  aes(x)) +
  geom_histogram(
    binwidth = 1,
    fill = "#C7CFE4",
    color = "#BDAFCA") +
  labs(
    title = "Fig 04: 泊松分布 (Poisson Distribution)",
    x = " 数值",
    y = " 频数") +
# Prevent the GBK character to show as block
  theme(
    text = element_text(
      family = "RLQDMSWR",
      size = 14))
```



```
# Task 05: Exponential Distribution
# Generate random values for exponential distribution
exponential_data =
  rexp(10000, rate = 0.5)

# Generate density plot
ggplot(
  data.frame(
    x = exponential_data),
  aes(x)) +
  geom_density() +
  labs(
    title = "Fig 05: 指数分布 (Exponential Distribution)",
    x = " 数值",
    y = " 密度") +
  # Prevent the GBK character to show as block
  theme(
    text = element_text(
      family = "RLQDMSWR",
      size = 14))
```

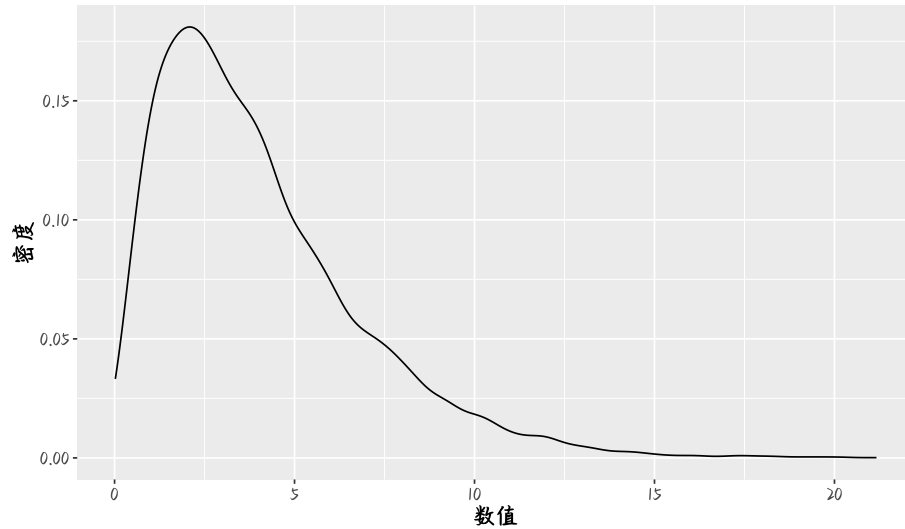
Fig 05: 指数分布 (Exponential Distribution)



```
# Task 06: Gamma Distribution
# Generate random values for gamma distribution
gamma_data =
  rgamma(10000, shape = 2, rate = 0.5)

# Generate density plot
ggplot(
  data.frame(
    x = gamma_data),
  aes(x)) +
  geom_density() +
  labs(
    title = "Fig 06: 伽马分布 (Gamma Distribution)",
    x = " 数值",
    y = " 密度") +
  # Prevent the GBK character to show as block
  theme(text = element_text(
    family = "RLQDMSWR",
    size = 14))
```

Fig 06: 伽马分布 (Gamma Distribution)



- 分组的问题

- 什么是 `equal-sized bin` 和 `equal-distance bin`? 以 `mtcars` 为例, 将 `wt` 列按两种方法分组, 并显示结果。

**Answer:**

- Equal-sized bin (等宽分组): 在这种分组方法中, 数据被分成具有相同宽度或大小的区间 (bin) 或组。这意味着每个分组具有相同数量的数据点, 但这可能导致一些分组的范围内包含更多或更少的数据点, 具体取决于数据的分布。
- Equal-distance bin (等距分组): 这种分组方法将数据按照等距离间隔的方式分成分组。区间的宽度可能不同, 但每个区间都覆盖了相等的数值范围。这意味着每个分组的数据点的范围是相等的, 但每个分组可能包含不同数量的数据点, 具体取决于数据的分布。

```
## 代码写这里，并运行；
```

```
library(dplyr)
```

```
##
```

```
## Attaching package: 'dplyr'
```

```
## The following objects are masked from 'package:stats':
```

```
##
```

```
##      filter, lag
```

```
## The following objects are masked from 'package:base':
```

```
##
```

```
##      intersect, setdiff, setequal, union
```

```
# Use equal-width grouping to
```

```
# divide wt columns into 5 groups
```

```
mtcars_equal_width =
```

```
  mtcars %>%
```

```
  mutate(
```

```
    wt_group_equal_width =
```

```
    cut(wt,
```

```
        breaks = 5,
```

```
        labels = FALSE))
```

```
head(mtcars_equal_width)
```

```
##           mpg cyl  disp  hp  drat    wt  qsec vs am gear carb
## Mazda RX4      21.0   6  160 110  3.90  2.620 16.46  0  1    4    4
## Mazda RX4 Wag  21.0   6  160 110  3.90  2.875 17.02  0  1    4    4
## Datsun 710     22.8   4  108  93  3.85  2.320 18.61  1  1    4    1
## Hornet 4 Drive  21.4   6  258 110  3.08  3.215 19.44  1  0    3    1
## Hornet Sportabout 18.7   8  360 175  3.15  3.440 17.02  0  0    3    2
## Valiant        18.1   6  225 105  2.76  3.460 20.22  1  0    3    1
```

```
##                               wt_group_equal_width
## Mazda RX4                      2
## Mazda RX4 Wag                  2
## Datsun 710                     2
## Hornet 4 Drive                 3
## Hornet Sportabout             3
## Valiant                       3
```

```
# Use isometric grouping to
# divide wt columns into 5 groups
mtcars_equal_distance =
  mtcars %>%
  mutate(
    wt_group_equal_distance =
      cut_interval(wt,
                    n = 5))

head(mtcars_equal_distance)
```

```
##           mpg cyl disp  hp drat   wt  qsec vs am gear carb
## Mazda RX4    21.0   6  160 110 3.90 2.620 16.46  0  1   4    4
## Mazda RX4 Wag 21.0   6  160 110 3.90 2.875 17.02  0  1   4    4
## Datsun 710    22.8   4  108  93 3.85 2.320 18.61  1  1   4    1
## Hornet 4 Drive 21.4   6  258 110 3.08 3.215 19.44  1  0   3    1
## Hornet Sportabout 18.7   8  360 175 3.15 3.440 17.02  0  0   3    2
## Valiant      18.1   6  225 105 2.76 3.460 20.22  1  0   3    1
##                               wt_group_equal_distance
## Mazda RX4                      (2.3,3.08]
## Mazda RX4 Wag                  (2.3,3.08]
## Datsun 710                     (2.3,3.08]
## Hornet 4 Drive                 (3.08,3.86]
## Hornet Sportabout             (3.08,3.86]
## Valiant                       (3.08,3.86]
```

---

- boxplot 中 outlier 值的鉴定

- 以 `swiss$Infant.Mortality` 为例, 找到它的 outlier 并打印出来;

```
## 代码写这里, 并运行;
# Load the data
data(swiss)

# Select the columns to look for outliers
infant_mortality =
  swiss$Infant.Mortality

# Calculate quartiles
Q1 =
  quantile(infant_mortality, 0.25)
Q3 =
  quantile(infant_mortality, 0.75)

# Calculate IQR
IQR = Q3 - Q1

# Calculate upper and lower limit
upper_limit =
  Q3 + 1.5 * IQR
lower_limit =
  Q1 - 1.5 * IQR

# Find the outlier
outliers =
  infant_mortality[
    infant_mortality > upper_limit |
```



```
    infant_mortality < lower_limit]

# 打印异常值
cat(
  "Infant Mortality Outliers:",
  outliers,
  "\n")
```

```
## Infant Mortality Outliers: 10.8
```

---

- 以男女生步数数据为例，进行以下计算：

首先用以下代码装入 Data:

```
source("../data/talk10/input_data1.R"); ## 装入 Data data.frame ...
head(Data);
```

```
##   Student    Sex Teacher Steps Rating
## 1      a female  Catbus  8000      7
## 2      b female  Catbus  9000     10
## 3      c female  Catbus 10000      9
## 4      d female  Catbus  7000      5
## 5      e female  Catbus  6000      4
## 6      f female  Catbus  8000      8
```

- 分别用``t.test``和``wilcox.test``比较男女生步数是否有显著差异；打印出``p.value``

```
## 代码写这里，并运行；
data_df = as.data.frame(Data)

# Task 01:
```

```
# Use t.test to compare  
# whether there is a significant difference  
# in the number of steps  
# taken by male and female students  
t_test_result = t.test(Steps ~ Sex, data = data_df)  
cat("t-test p.value:", t_test_result$p.value, "\n")
```

```
## t-test p.value: 0.01461209
```

```
# Task 02:  
# Using wilcox.test to compare  
# whether there is a significant difference  
# in the number of steps  
# taken by male and female students  
wilcox_test_result = wilcox.test(Steps ~ Sex, data = data_df)  
cat("Wilcoxon rank sum test p.value:", wilcox_test_result$p.value, "\n")
```

```
## Wilcoxon rank sum test p.value: 0.01773304
```

- 两种检测方法的`p.value`哪个更显著？为什么？

答：

**AWAITING PERFECTION**

- 
- 以下是学生参加辅导班前后的成绩情况，请计算同学们的成绩是否有普遍提高？

注：先用以下代码装入数据：

```
source("../data/talk10/input_data2.R");  
head(scores);
```

```
##      Time Student Score  
## 1 Before      a     65  
## 2 Before      b     75  
## 3 Before      c     86  
## 4 Before      d     69  
## 5 Before      e     60  
## 6 Before      f     81
```

注：计算时请使用 `paired = T` 参数；

```
## 代码写这里，并运行；  
score_df = as.data.frame(scores)  
  
# Execute paired t-test  
t_test_result =  
  t.test(Score ~ Time,  
         data = score_df,  
         paired = TRUE)  
  
# Print the result  
cat(  
  "Paired t-test p.value:",  
  t_test_result$p.value,  
  "\n")
```

```
## Paired t-test p.value: 0.004163495
```

```
# Check if the p-value is  
# less than the level of significance,  
# e.g. 0.05
```

```

if (t_test_result$p.value < 0.05) {
  cat("Student achievement has generally improved.\n")
} else {
  cat("There is insufficient evidence of a general improvement in student achievement.\n")
}

```

```
## Student achievement has generally improved.
```

## 0.5 练习与作业 2: 作图

- 利用 talk10 中的 data.fig3a 作图

– 首先用以下命令装入数据:

```

library(tidyverse);

## -- Attaching core tidyverse packages ----- tidyverse 2.0.0 --
## v forcats 1.0.0      v stringr 1.5.0
## v lubridate 1.9.2    v tibble 3.2.1
## v purrr 1.0.2       v tidyr 1.3.0
## v readr 2.1.4
## -- Conflicts ----- tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()     masks stats::lag()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts

data.fig3a <- read_csv( file = "../data/talk10/nc2015_data_for_fig3a.csv" ,show_col_type=TRUE)

```

- 利用两列数据: `tai` `zAA1.at` 做`talk10`中的`boxplot` (详见: `fig3a`的制作);
- 用`ggsignif`为相邻的两组做统计分析 (如用 `wilcox.test` 函数), 并画出`p.value`;

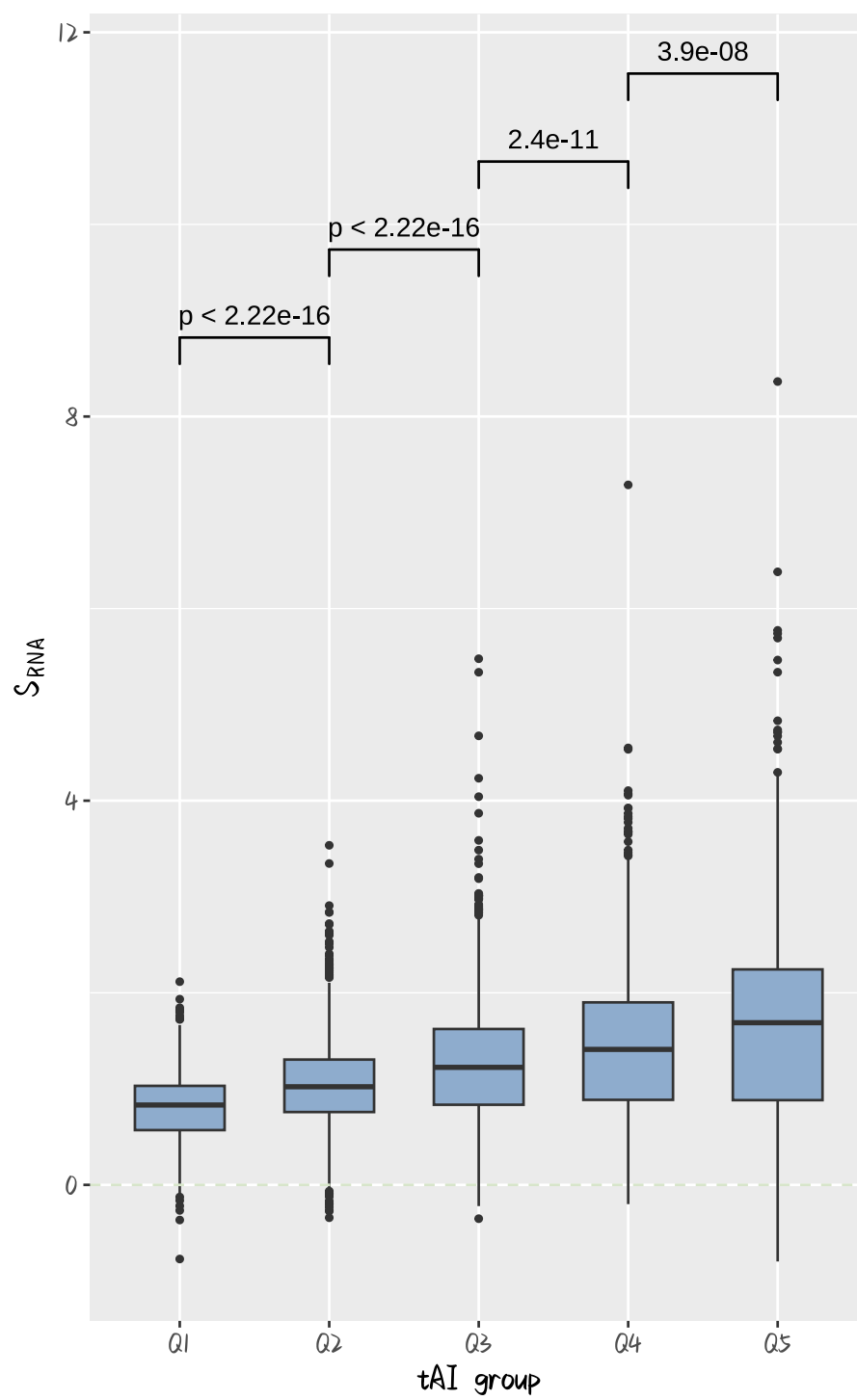
```
## 代码写这里，并运行；
library(tidyverse)
library(ggsignif)

fig3a_df = as.data.frame(data.fig3a)

# Draw the basic boxplot
fig3a_boxplot =
  ggplot( fig3a_df,
          aes( factor(tai), zAA1.at ) ) +
  geom_boxplot(
    fill = "#8EACCD",
    linetype = 1 ,
    outlier.size = 1,
    width = 0.6) +
  xlab( "tAI group" ) +
  ylab( expression( paste( italic(S[RNA]) ) ) ) +
  scale_x_discrete(
    breaks= 1:5 ,
    labels= paste("Q", 1:5, sep = "" ) +
  geom_hline(
    yintercept = 0,
    colour = "#D7E5CA",
    linetype = 2) +
  theme(
    text=element_text(
      family="RLQDMSWR",
      size=14))

# Add p.value
fig3a_boxplot_signif =
  fig3a_boxplot +
```

```
geom_signif(  
  comparisons = list(1:2, 2:3, 3:4, 4:5),  
  test = wilcox.test,  
  step_increase = 0.1 )  
  
print(fig3a_boxplot_signif)
```



问：这组数据可以用 `t.test` 吗？为什么？

答：

不可以，不满足 `t-test` 的先决条件，如果运行下列 `t.test` 的代码将会报错：

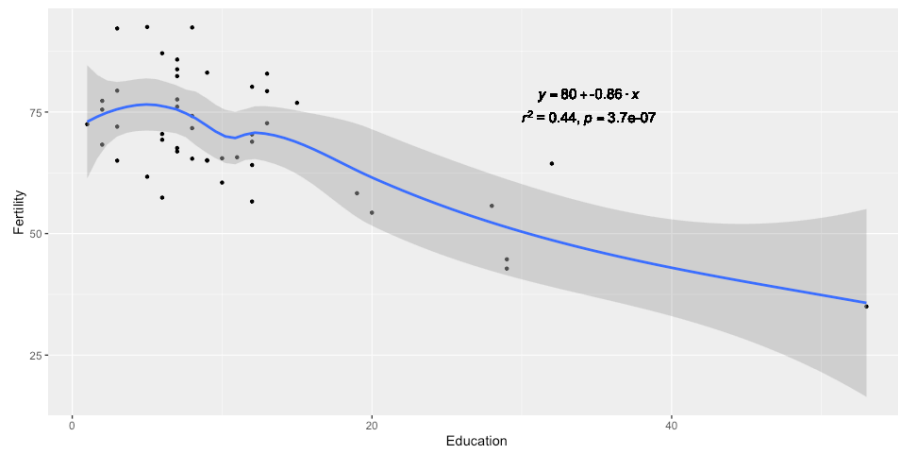
```
# Take the first 200 rows of data  
# to avoid exceeding the test range  
fig3a_df_test = fig3a_df[1:200,]  
  
# Carry out the examination  
shapiro_test =  
  shapiro.test(fig3a_df_test$zAA1.at)  
levene_test =  
  car::leveneTest(  
    fig3a_df_test$zAA1.at ~ fig3a_df_test$tai,  
    data = fig3a_df_test)
```

---

- 用系统自带变量 `mtcars` 做图

- 用散点图表示 `wt` (x-轴) 与 `mpg` (y-轴) 的关系
- 添加线性回归直线图层
- 计算 `wt` 与 `mpg` 的相关性，并将结果以公式添加到图上。其最终效果如下图所示（注：相关代码可在 `talk09` 中找到）：





```
## 代码写这里，并运行；
library(ggplot2)

data("mtcars")
# Creating Scatterplots
scatter_plot_mtcars =
  ggplot(mtcars,
    aes(x = wt, y = mpg)) +
  geom_point() +
  geom_smooth(color = "#A4B0FA") +
  labs(
    title = "Scatter Plot of Weight vs. MPG",
    x = "Weight",
    y = "MPG") +
  theme(
    text=element_text(
      family="RLQDMSWR",
      size=14))

# Calculate Correlation
mtcars_correlation =
  cor(mtcars$wt, mtcars$mpg)
```

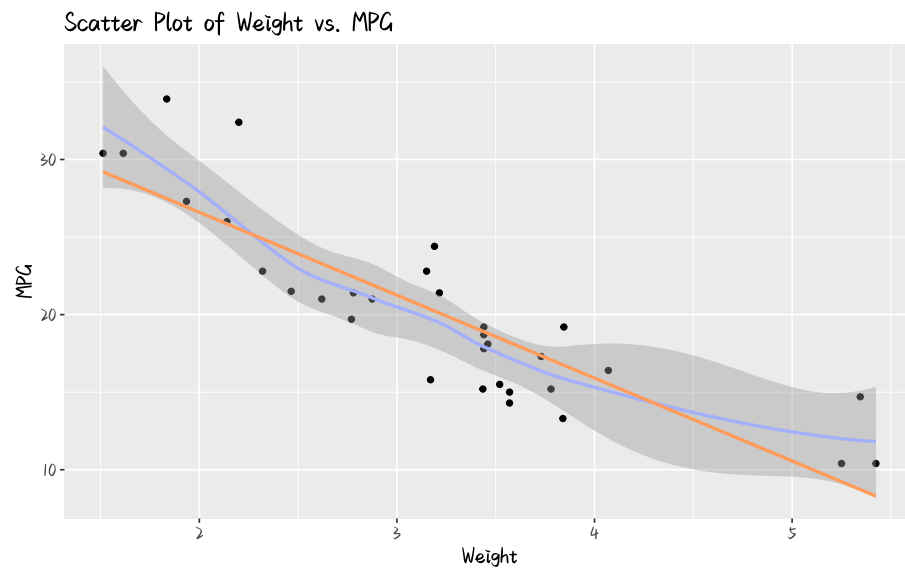
```
# Draw the plot
scatter_plot_with_regression =
  scatter_plot_mtcars +
  # Add a linear regression line
  geom_smooth(method = "lm", se = FALSE, color = "#FF9C5B")

  # Add correlation formula

  # AWAITING PERFECTION
  # annotate("text", x = 4, y = 30, label = paste("Correlation:", round(correlation, 2))

# Print scatter plots and
# linear regression lines
print(scatter_plot_with_regression)

## `geom_smooth()` using method = 'loess' and formula = 'y ~ x'
## `geom_smooth()` using formula = 'y ~ x'
```

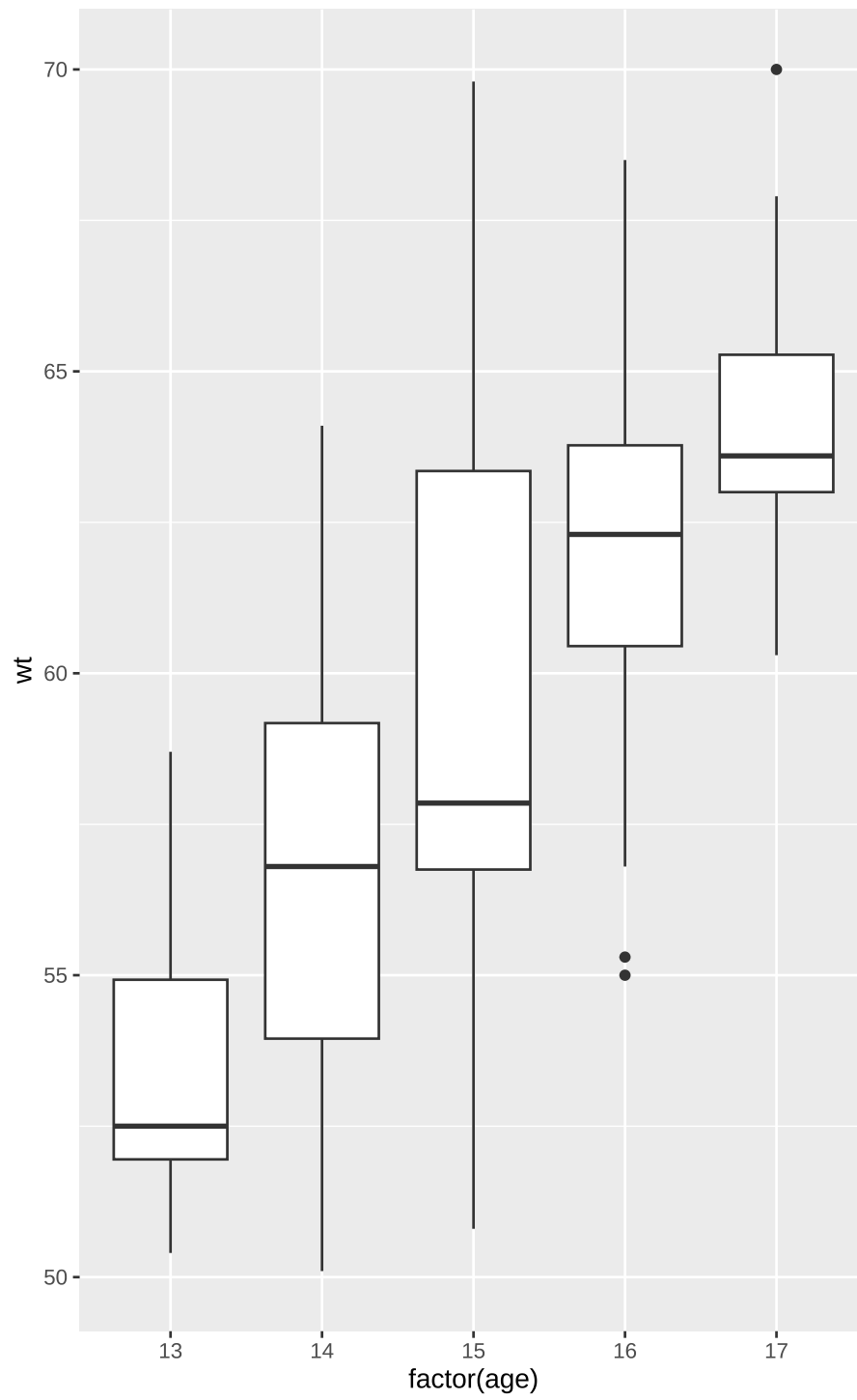


## 0.6 练习与作业 3：线性模型与预测

---

- 使用以下代码产生数据进行分析

```
wts2 <- bind_rows(  
  tibble( class = 1, age = sample( 13:15, 20, replace = T ), wt = sample( seq(50, 60,  
  tibble( class = 2, age = sample( 14:16, 20, replace = T ), wt = sample( seq(55, 65,  
  tibble( class = 3, age = sample( 15:17, 20, replace = T ), wt = sample( seq(60, 70,  
);  
  
ggplot(wts2, aes( factor( age ), wt ) ) + geom_boxplot() ;
```



- 用线性回归检查`age`、`class`与`wt`的关系，构建线性回归模型；
- 以`age`、`class`为输入，用得到的模型预测`wt`；
- 计算预测的`wt`和实际`wt`的相关性；
- 用线性公式显示如何用`age`、`class`计算`wt`的值。

```
## 代码写这里，并运行；
library(ggplot2)
library(dplyr)

# Create data.frame
wts2 = bind_rows(
  tibble( class = 1, age = sample( 13:15, 20, replace = T ), wt = sample( seq(50, 60,
  tibble( class = 2, age = sample( 14:16, 20, replace = T ), wt = sample( seq(55, 65,
  tibble( class = 3, age = sample( 15:17, 20, replace = T ), wt = sample( seq(60, 70,
)

# Draw Scatter Plot
wts2_scatter_plot =
  ggplot(wts2, aes(x = age, y = wt)) +
  geom_point() +
  geom_smooth(color = "#377177")
  theme(
    text=element_text(
      family="RLQDMSWR",
      size=14)) +
  labs(
    title = "Scatter Plot of Age vs. Weight",
    x = "Age",
    y = "Weight")

## List of 4
```

```
## $ text :List of 11
## ..$ family      : chr "RLQDMSWR"
## ..$ face        : NULL
## ..$ colour      : NULL
## ..$ size        : num 14
## ..$ hjust       : NULL
## ..$ vjust       : NULL
## ..$ angle       : NULL
## ..$ lineheight  : NULL
## ..$ margin      : NULL
## ..$ debug       : NULL
## ..$ inherit.blank: logi FALSE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ x      : chr "Age"
## $ y      : chr "Weight"
## $ title: chr "Scatter Plot of Age vs. Weight"
## - attr(*, "class")= chr [1:2] "theme" "gg"
## - attr(*, "complete")= logi FALSE
## - attr(*, "validate")= logi TRUE
```

```
# Add a linear regression line
wts2_scatter_plot_with_regression =
  wts2_scatter_plot +
  geom_smooth(
    method = "lm",
    se = FALSE,
    color = "#2B484E")

# Constructing a linear regression model
linear_model =
  lm(wt ~ age + class, data = wts2)

# Forecast wt
predicted_wt =
```

```
predict(
  linear_model,
  newdata =
    data.frame(
      age = wts2$age,
      class = wts2$class))

# Calculate the correlation
# between actual wt and predicted wt
correlation =
  cor(wts2$wt, predicted_wt)

# Print relevance
cat("Correlation between Actual Weight and Predicted Weight:", correlation, "\n")

## Correlation between Actual Weight and Predicted Weight: 0.8240552

# Print the formula
cat("Linear Regression Formula: wt = ", round(coef(linear_model)[1], 2), " + ", round(c

## Linear Regression Formula: wt = 57.11 + -0.54 * age + 5.56 * class

# AWAITING PERFECTION:
# Insert the formula into the figure
```