Design of experiment - Homework 01

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※ Exercise2.3

Suppose we are studying the effect of diet on height of children, and we have two diets to compare: diet A (a well balanced diet with lots of broccoli) and diet B (a diet rich in potato chips and candy bars). We wish to find the diet that helps children grow (in height) fastest. We have decided to use 20 children in the experiment, and we are contemplating the following methods for matching children with diets:

1. Let them choose.
2. Take the first 10 for A, the second 10 for B.
3. Alternate A, B, A, B.
4. Toss a coin for each child in the study: heads → A, tails → B.
5. Get 20 children; choose 10 at random for A, the rest for B.

Describe the benefits and risks of using these five methods.

1. 使用此方法的好處在於完全將選擇權交付於小孩身上，讓小孩選擇喜歡的食物去食用。在醫學研究上，好的心理狀態、快樂對於孩童的身心發展是有正面的影響，而且這個方法也可以很快完成實驗配置。但壞處在於可能兩種方法會有一種方法完全沒有人選，並非所有小孩都喜歡花椰菜，雖然均衡飲食對於孩童生長是有利的，但個人好惡會影響選擇、進食與否，因此可能會有餐點選項會沒人選擇。因此這是個不好的配置方式。
2. 這方法好處在於孩童快速配置實驗，但存在孩童排列順序的問題（即使用特定特徵，如身高、體重進行孩童排列順序），可能因為孩童排列順序的不同造成非飲食實驗誤差產生，且無法做統計估計以及此方法並非隨機化的。
3. 同第二個方法，都有孩童排列順序的非實驗誤差存在，應盡量將這種非實驗誤差減少，且無法做統計估計。
4. 假設這枚硬幣出現正反面的機率都是相同公正下，出現正反面的機率都是 0.5，即孩童被分配到 diet A 跟 diet B 機率都一樣，因此這枚硬幣即會消除個人好惡以及排列順序的非實驗誤差。再者，這樣的配置方式是一種隨機化的方法，可方便適用於統計估計上。但缺點是若這枚硬幣非公正(正反面出現機率不同)，則有很大的機會發生 diet A 或 diet B 完全沒被分配到，造成實驗無法進行。
5. 在選擇孩童分配 diet A 跟 diet B 時是隨機抽取，從 20 位孩童中隨機抽取 10 位選為 diet A, 因此每位孩童被選為 diet A 的機率為$\frac{\binom{10}{1}}{\binom{20}{1}} = 0.5$, 等同於被選為 diet B 的機率，因此這樣的配置方式為一種隨機化的方法，能避免了排列順序以及個人好惡的誤差產生，也可以避免性別誤差，同時這樣的方法也能運用統計估計去推估兩個飲食方法是否有顯著差異。

※ Exercise2.5

Chu (1970) studied the effect of the insecticide chlordane on the ner- vous systems of American cockroaches. The coxal muscles from one meso- and one metathoracic leg on opposite sides were surgically extracted from each of six roaches. The roaches were then treated with 50 micrograms of α-chlordane, and coxal muscles from the two remaining meso- and metatho- racic legs were removed about two hours after treatment. The Na^+ -K^+ ATPase activity was measured in each muscle, and the percentage changes for the six roaches are given here:

15.3 -31.8 -35.6 -14.5 3.1 -24.5

Test the null hypothesis that the chlordane treatment has not affected the Na^+-K^+ATPas activity. What experimental technique (not mentioned in the description above) must have been used to justify a randomization test?

H_0 : The chlordane treatment has not affected the Na^+-K^+ATPas activity.

H_1 : The chlordane treatment has affected the Na^+-K^+ATPas activity.

為避免非實驗誤差產生，有以下假設需建立

蟑螂品種、大小、注射方式、注射環境、實驗環境為一致，蟑螂在此實驗之前未經過任何實驗(屏除其他實驗殘留的誤差)，而選取蟑螂的方式為隨機選取。

在H_0為真下，這組樣本資料有64種可能的隨機結果，然後使用 $\frac{\sum_{i=1}^{6} x_i}{s_x/\sqrt{n}}$ 來做為統計量 。(x_i為觀測值)

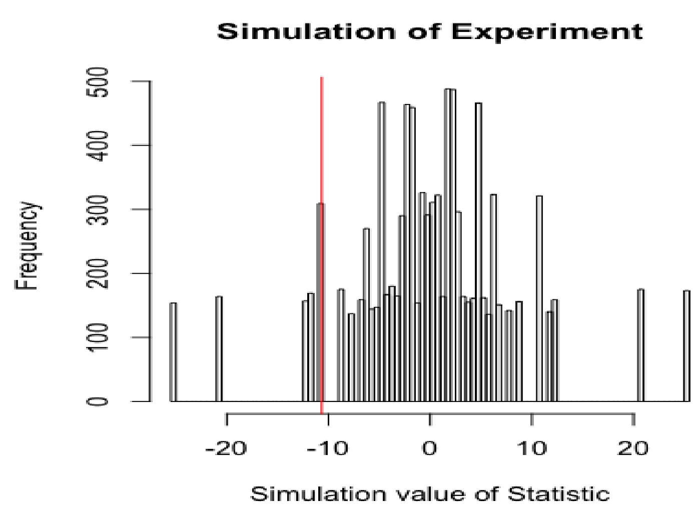
將64種隨機結果隨機模擬出一萬筆數值，繪成直方圖，並計算P值(雙尾檢定，顯著水準$\alpha = 0.05$)。

這邊只列出結果及圖。(Code 附在 Appendix 1)

模擬結果P值為0.16(將此模擬實驗進行100次，並收集每次實驗的P值，再取平均值，標準差為0.0026)

因為P值 = 0.16 > 0.05，不拒絕H_0的假設。(紅線為臨界值 -11 ，P值為2倍的小於紅線值的機率（雙尾檢定）)

Conclusion: The chlordane treatment has not affected the Na^+-K^+ATPas activity.

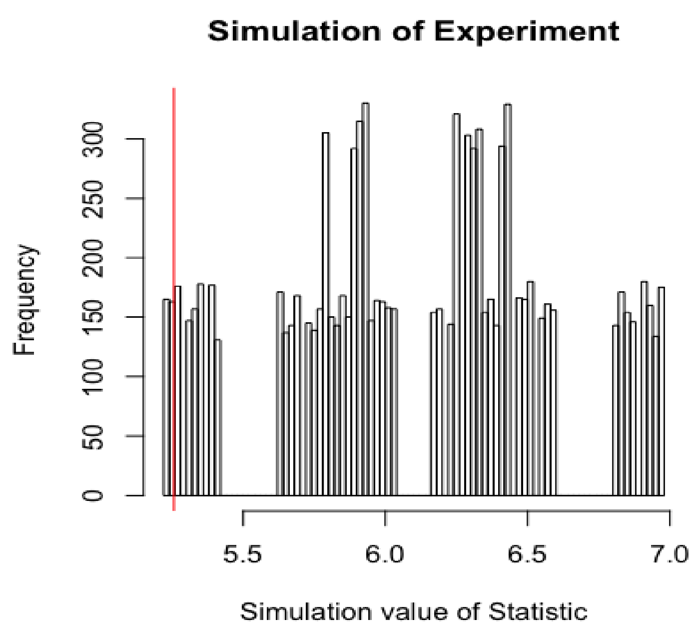


※Problem2.1

McElhoe and Conner (1986) use an instrument called a “Visiplume” to measure ultraviolet light. By comparing absorption in clear air and absorption in polluted air, the concentration of SO_2 in the polluted air can be estimated. The EPA has a standard method for measuring SO_2, and we wish to compare the two methods across a range of air samples. The recorded response is the ratio of the Visiplume reading to the EPA standard reading. There were six observations on coal plant number 2: .950, .978, .762, .733, .823, and 1.011. If we make the null hypothesis be that the Visiplume and standard measurements are equivalent (and the Visiplume and standard labels are just labels and nothing more), then the ratios could (with equal probability) have been observed as their reciprocals. That is, the ratio of .950 could with equal probability have been 1/.950 = 1.053, since the labels are equivalent and assigned at random. Suppose we take as our summary of the data the sum of the ratios. We observe .95 + ... + 1.011 = 5.257. Test (using randomization methods) the null hypothesis of equivalent measurement procedures against the alternative that Visiplume reads higher than the standard. Report a p-value.

H0: The ratio of the Visiplume reading to the EPA standard reading equals to 1.
H1: The ratio of the Visiplume reading to the EPA standard reading greater than 1.

在H_0為真下，這組樣本資料有64種可能的隨機結果，然後使用$\sum_{i=1}^{6} x_i$來做為統計量。(x_i為觀測值)
將64種隨機結果用亂數模擬出一萬筆數值，繪成直方圖，並計算P值(右尾檢定，設顯著水準$\alpha = 0.05$)
這邊只列出結果及圖(Code 附在 Appendix 2)
模擬結果P值為0.97(將此模擬實驗進行100次，並收集每次實驗的P值，再取平均值，標準差0.0019)
因為P值 = 0.97 > 0.05，不拒絕H_0的假設。(紅線為臨界值 5.3 ，P值為大於紅線值的機率)
Conclusion: The ratio of the Visiplume reading to the EPA standard reading equals to 1.



※Appendix

Appendix 1

```
library(dplyr)

# Exercise 2.5 蟑螂 #
# H0 : The chlordane treatment has not affected the Na+-K+ATPas activity. #
# H1 : The chlordane treatment has affected the Na+-K+ATPas activity. #
pv = NULL
for (j in 1:100){
# Data
d <- c(15.3, -31.8, -35.6, -14.5, 3.1, -24.5)
# Number of simulation #
N <- 10000
# Define function #
ttest <- function(d1){
  d_sum <- sum(d1)
  ds <- sd(d1)
  t <- d_sum/ds*sqrt(6)
  return(t)}

temp <- NULL
for( i in 1:N){
  number <- sample(0:6,1,T,prob = c(1,6,15,20,15,6,1)/64)
  if(number != 0 ){
    sign <- sample(1:6,number,F)
    d1 <- c(d[sign]*-1,d[-sign])}
  else{d1 <- d}
  temp <- c(temp,ttest(d1))}

# crititcal point #
P_value <- sum(ttest(d) > temp)/N
pv <- c(pv, P_value)}

# p value and it's standaed error
P_value <- mean(pv)*2
P_value

## [1] 0.15681

sd <- sd(pv)
sd

## [1] 0.002828512

# Under alpha = 0.05 , P value < alpha,  Reject H0 #

# Histogram #
# Red Line is critical value #
hist(temp,100, main = 'Simulation of Experiment', xlab = 'Simulation value of Statistic')
abline( v = ttest(d), col = 'red')
```

Appendix 2

```
# Exercise Promblem 2.1 #
# H0 : The null hypothesis is that Visiplume reads equal the standard.
# H1 : The alternative hypothesis is that Visiplume reads higher than the standard.
x <- c(0.95, 0.978, 0.762, 0.733, 0.823, 1.011)
N <- 10000
pv <- NULL
for(i in 1:100){
  temp <- NULL
  for(j in 1:N){
    y <- NULL
    sign <- sample(c(1,-1),6,prob = c(0.5,0.5),T)
      for(i in 1:6){
        if(sign[i] == -1){
          y[i] <-  1/x[i]}
          else{y[i] <-  x[i]}}
   temp <- c(temp,sum(y))}
  P_value <- sum(sum(x) < temp)/N
  pv <- c(pv,P_value)}

# p value and it's standaed error
P_value <- mean(pv)
P_value

## [1] 0.96878

sd <- sd(pv)
sd

## [1] 0.001820367

# Under alpha = 0.05 , P value > alpha,  Do not reject H0 #

# Histogram #
# Red line is critical value #
hist(temp,100, main = 'Simulation of Experiment', xlab = 'Simulation value of Statistic')
abline( v = sum(x), col = 'red')
```

附上 RPbus 連結: http://rpubs.com/YaPi/369025