

# STATS 205: Homework Assignment 4

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## Solution to Problem 1

```
allergics = c(1651.0, 1112.0, 102.4, 100.0, 67.6, 65.9, 64.7, 39.6, 31.0)
nonallergics = c(48.1, 48.0, 45.5, 41.7, 35.4, 34.3, 32.4, 29.1, 27.3, 18.9, 6.6, 5.2, 4.7)
allergics; nonallergics
```

```
## [1] 1651.0 1112.0 102.4 100.0 67.6 65.9 64.7 39.6 31.0
```

```
## [1] 48.1 48.0 45.5 41.7 35.4 34.3 32.4 29.1 27.3 18.9 6.6 5.2 4.7
```

The null hypothesis is that allergic smokers have the same sputum histamine levels as nonallergic smokers. That is,

$$H_0 : p_a = p_n$$

The alternative hypothesis is that allergic smokers have higher sputum histamine levels than nonallergic smokers. That is,

$$H_0 : p_a > p_n$$

To test the null hypothesis against the alternative hypothesis, we will use the Mann-Whitney-Wilcoxin test, since the two samples are independent.

Two data samples are independent if they come from distinct populations and the samples do not affect each other. – Mann-Whitney-Wilcoxin Test

```
wilcox.test(x = allergics, y = nonallergics, alternative = "greater")
```

```
##
```

```
## Wilcoxon rank sum test
```

```
##
```

```
## data: allergics and nonallergics
```

```
## W = 106, p-value = 0.000386
```

```
## alternative hypothesis: true location shift is greater than 0
```

The  $p$ -value is 0.000386, which is significant at the  $\alpha = 0.05$  level. There is strong evidence that allergic smokers have higher sputum histamine levels than nonallergic smokers.

## Solution to Problem 2

Original problem statement

```
karate = c(37, 39, 30, 7, 13, 139, 45, 25, 16, 146, 94, 16, 23, 1, 290, 169, 62, 145, 36, 20, 13)
olympics = c(12, 44, 34, 14, 9, 19, 156, 23, 13, 11, 47, 26, 14, 33, 15, 62, 5, 8, 0, 154, 146)
karate; olympics
```

```
## [1] 37 39 30 7 13 139 45 25 16 146 94 16 23 1 290 169 62
```

```
## [18] 145 36 20 13
```

```
## [1] 12 44 34 14 9 19 156 23 13 11 47 26 14 33 15 62 5
## [18] 8 0 154 146
```

The null hypothesis is that children who viewed the violent TV take the same amount of time to seek help (were as tolerant) as the children who viewed the nonviolent sports-action TV. That is,

$$H_0 : t_k = t_o$$

The alternative hypothesis is that children who viewed the violent TV take longer to seek help (were more tolerant) than the children who viewed the nonviolent sports-action TV. That is,

$$H_0 : t_k > t_o$$

```
wilcox.test(x = karate, y = olympics, alternative = "greater")
```

```
## Warning in wilcox.test.default(x = karate, y = olympics, alternative =
## "greater"): cannot compute exact p-value with ties
##
## Wilcoxon rank sum test with continuity correction
##
## data: karate and olympics
## W = 276.5, p-value = 0.08126
## alternative hypothesis: true location shift is greater than 0
```

The  $p$ -value is 0.08126, which is *not* significant at the  $\alpha = 0.05$  level. There is *not enough* evidence that children who viewed the violent TV take longer to seek help (were more tolerant) than the children who viewed the nonviolent sports-action TV.

### Solution to Problem 3

Let  $X$  be the nonallergics and  $Y$  be the allergics.

$$\delta = P(X < Y)$$

```
allergics = c(1651.0, 1112.0, 102.4, 100.0, 67.6, 65.9, 64.7, 39.6, 31.0)
nonallergics = c(48.1, 48.0, 45.5, 41.7, 35.4, 34.3, 32.4, 29.1, 27.3, 18.9, 6.6, 5.2, 4.7)
allergics; nonallergics
```

```
## [1] 1651.0 1112.0 102.4 100.0 67.6 65.9 64.7 39.6 31.0
## [1] 48.1 48.0 45.5 41.7 35.4 34.3 32.4 29.1 27.3 18.9 6.6 5.2 4.7
wilcox.test(x = allergics, y = nonallergics, conf.int=TRUE, conf.level=.90)

##
## Wilcoxon rank sum test
##
## data: allergics and nonallergics
## W = 106, p-value = 0.000772
## alternative hypothesis: true location shift is not equal to 0
## 90 percent confidence interval:
## 25.9 81.1
## sample estimates:
## difference in location
```

```
## 54.3
```

The estimate for  $\delta$  is

$$\hat{\delta} = P(X < Y) = 54.3$$

and the 90 confidence interval for  $\delta$  is

$$\hat{\delta} = P(X < Y) = (25.9, 81.1)$$

## Solution to Problem 4

```
term = c(0.80, 0.83, 1.89, 1.04, 1.45, 1.38, 1.91, 1.64, 0.73, 1.46)
gest = c(1.15, 0.88, 0.90, 0.74, 1.21)

wilcox.test(x = term, y = gest, alternative = "greater")
```

```
##
## Wilcoxon rank sum test
##
## data: term and gest
## W = 35, p-value = 0.1272
## alternative hypothesis: true location shift is greater than 0
```

```
# ks.test(x = term, y = gest, alternative = "greater")
# ks.test(x = term, y = gest)
```

The  $p$ -value for the Wilcoxon ranked test is 0.1272.

The  $p$ -value for the one-sided Two-sample Kolmogorov-Smirnov test is 0.9355, which is larger than the  $p$ -value for the Wilcoxon ranked test.

The  $p$ -value for the two-sided Two-sample Kolmogorov-Smirnov test is 0.1658, which is similar to that of the Wilcoxon ranked test.

```
# install.packages("npsm", dependencies = TRUE, repos = "http://cran.us.r-project.org")
# install.packages("RVAideMemoire", dependencies = TRUE, repos = "http://cran.us.r-project.org")
# install.packages("robustrank", dependencies = TRUE, repos = "http://cran.us.r-project.org")
# fp.test(x = term, y = gest, alternative = 'two.sided')
# fp.test(x = term, y = gest)
```

Unfortunately, the package for `fp.test()` doesn't seem to be within reach, despite installing the following packages:

- npsm package
- RVAideMemoire package, with `fp.test()` demonstrated here
- R Documentation of npsm package including `fp.test()`
- robustrank package

## Solution to Problem 5

Null hypothesis: “equal dispersions”

$$H_0 : p_{term} = p_{gest}$$

Alternative hypothesis: “the variation in tritiated water diffusion across human chorioamnion is different at term than at 12–26 weeks gestational age”

$$H_A : p_{term} \neq p_{gest}$$

```
term = c(0.80, 0.83, 1.89, 1.04, 1.45, 1.38, 1.91, 1.64, 0.73, 1.46)
gest = c(1.15, 0.88, 0.90, 0.74, 1.21)

ansari.test(x = term, y = gest, alternative = "t")
```

```
##
##  Ansari-Bradley test
##
## data:  term and gest
## AB = 36, p-value = 0.1372
## alternative hypothesis: true ratio of scales is not equal to 1
```

The  $p$ -value is 0.1372, which is *not* significant at the  $\alpha = 0.05$  level. There is *not enough* evidence that the variation in tritiated water diffusion across human chorioamnion is different at term than at 12–26 weeks gestational age.

## Solution to Problem 6

```
a = c(3.6, 2.6, 4.7, 8.0, 3.1, 8.8, 4.6, 5.8, 4.0, 4.6)
b = c(16.2, 17.4, 8.5, 15.6, 5.4, 9.8, 14.9, 16.6, 15.9, 5.3, 10.5)
```

The null hypothesis is that Type A subjects have the same Peak Levels of Human Plasma Growth Hormone after Arginine Hydrochloride Infusion as Type B subjects. That is,

$$H_0 : l_a = l_b$$

The alternative hypothesis is that Type A subjects have different Peak Levels of Human Plasma Growth Hormone after Arginine Hydrochloride Infusion as Type B subjects. That is,

$$H_0 : l_a > l_b$$

To test the null hypothesis against the alternative hypothesis, we will use the Mann-Whitney-Wilcoxin test, since the two samples are independent.

```
wilcox.test(x = a, y = b, alternative = "two.sided")
```

```
## Warning in wilcox.test.default(x = a, y = b, alternative = "two.sided"):
## cannot compute exact p-value with ties
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  a and b
## W = 7, p-value = 0.0008201
## alternative hypothesis: true location shift is not equal to 0
```

The  $p$ -value is 0.0008201, which is significant at the  $\alpha = 0.05$  level. There is *strong evidence* that Type A subjects have different Peak Levels of Human Plasma Growth Hormone after Arginine Hydrochloride Infusion as Type B subjects.

## Solution to Problem 7

```
Darwin.data = data.frame(pair = seq(1, 15), pot = c(rep(1, times=3), rep(2, times = 3), rep(3, times = 3), rep(4, times = 3)), cross.height = c(23.5, 12, 21, 22, 19.125, 21.5, 22.125, 20.375, 18.25, 21.625, 23.25, 21, 22.125, 23, 12), self.height = c(17.375, 20.375, 20, 20, 18.375, 18.625, 18.625, 15.25, 16.5, 18, 16.25, 18, 12.75, 15.5, 18))
```

```
Darwin.data
```

##	pair	pot	cross.height	self.height
## 1	1	1	23.500	17.375
## 2	2	1	12.000	20.375
## 3	3	1	21.000	20.000
## 4	4	2	22.000	20.000
## 5	5	2	19.125	18.375
## 6	6	2	21.500	18.625
## 7	7	3	22.125	18.625
## 8	8	3	20.375	15.250
## 9	9	3	18.250	16.500
## 10	10	3	21.625	18.000
## 11	11	3	23.250	16.250
## 12	12	4	21.000	18.000
## 13	13	4	22.125	12.750
## 14	14	4	23.000	15.500
## 15	15	4	12.000	18.000

```
saveRDS(Darwin.data, "Darwin_data.rds"); Darwin.data
```

##	pair	pot	cross.height	self.height
## 1	1	1	23.500	17.375
## 2	2	1	12.000	20.375
## 3	3	1	21.000	20.000
## 4	4	2	22.000	20.000
## 5	5	2	19.125	18.375
## 6	6	2	21.500	18.625
## 7	7	3	22.125	18.625
## 8	8	3	20.375	15.250
## 9	9	3	18.250	16.500
## 10	10	3	21.625	18.000
## 11	11	3	23.250	16.250
## 12	12	4	21.000	18.000
## 13	13	4	22.125	12.750
## 14	14	4	23.000	15.500
## 15	15	4	12.000	18.000

(i)

```
Darwin.data$cross.height
```

```
## [1] 23.500 12.000 21.000 22.000 19.125 21.500 22.125 20.375 18.250 21.625  
## [11] 23.250 21.000 22.125 23.000 12.000
```