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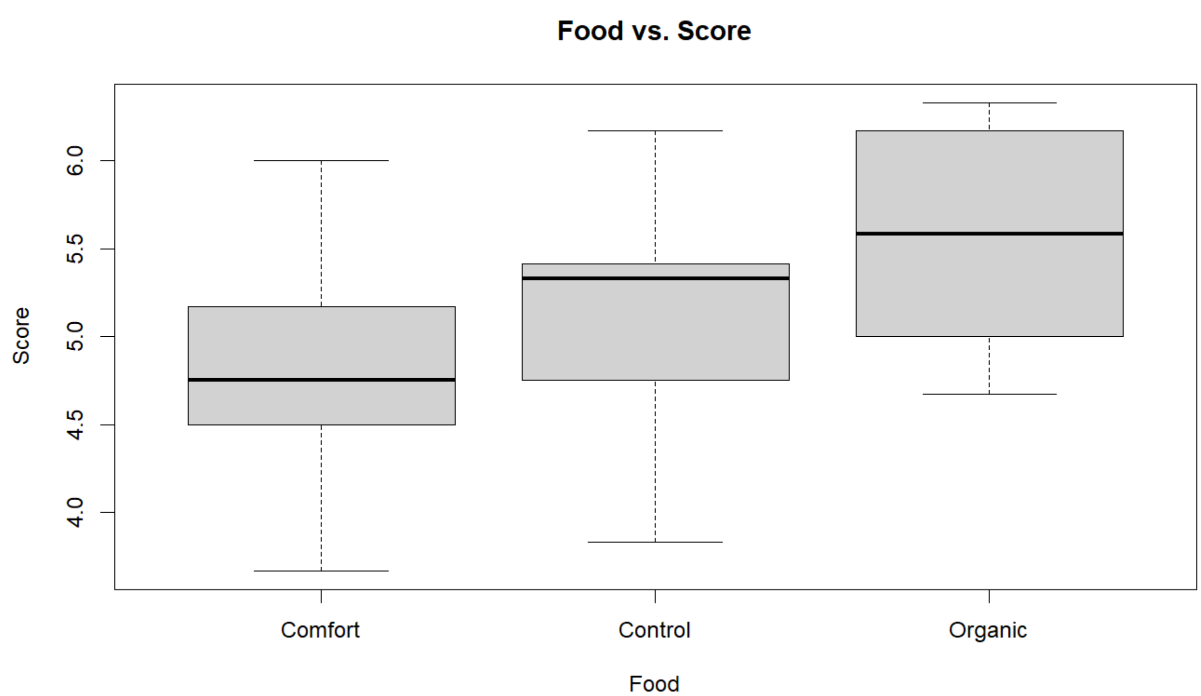
I pledge my honor that I have abided by the Stevens Honor System.

Problem 1

```
> library(readxl)
> Organic = read_excel("Organic.xls")
> Org_sc <- Organic[which(Organic$Food == "Organic"), "Score"]$Score
> Com_sc <- Organic[which(Organic$Food == "Comfort"), "Score"]$Score
> Ctl_sc <- Organic[which(Organic$Food == "Control"), "Score"]$Score
> length(Org_sc); mean(Org_sc); var(Org_sc)
[1] 20
[1] 5.5835
[1] 0.3523187
> length(Com_sc); mean(Com_sc); var(Com_sc)
[1] 22
[1] 4.887273
[1] 0.3282303
> length(Ctl_sc); mean(Ctl_sc); var(Ctl_sc)
[1] 20
[1] 5.0825
[1] 0.3864724
> boxplot(xlab = "Food", ylab = "Score", Organic$Score ~ Organic$Food, main =
"Food vs. Score")
```



Problem 2

```
> var.test(Ctl_sc, Com_sc, ratio = 1, alternative=c("two.sided"), alpha =
1-0.05)

      F test to compare two variances

data:  Ctl_sc and Com_sc
F = 1.1774, num df = 19, denom df = 21, p-value = 0.7128
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.4820835 2.9353080
sample estimates:
ratio of variances
          1.177443
```

The df for Control, the numerator, is 19 and it is 21 for the denominator, Comfort. This makes the testing statistic $F_{19,21}$. The p-value is 0.7128. At $\alpha = 0.05$, we cannot reject the null hypothesis and thus we assume $\sigma^2_{Control} = \sigma^2_{Comfort}$.

Problem 3

(i)

1 = Control, 2 = Comfort, 3 = Organic

3i)

$H_0: \mu_1 = \mu_2$, $H_a: \mu_1 \neq \mu_2$

$$t = \frac{\bar{x}_1 - \bar{x}_2}{S_p \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \qquad S_p^2 = \frac{(n_1-1)\,S_1^2 + (n_2-1)\,S_2^2}{n_1+n_2-2}$$

$$df = n_1 + n_2 - 2$$

```
> # 3i: Getting the testing statistic/df/p-val
> t.test(Ctl_sc, Com_sc, var.equal=TRUE)

      Two Sample t-test

data:  Ctl_sc and Com_sc
t = 1.0592, df = 40, p-value = 0.2959
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.1772862  0.5677407
sample estimates:
mean of x mean of y
 5.082500  4.887273
```

(ii)

3ii)
$p = 0.3 > \alpha = 0.01$, so we don't reject the null hypothesis; no significant difference between control & comfort

Problem 4

(i)

```
> # 4i: Get overall avg, group avgs, group vars
> overall_avg <- round(mean(Organic$Score), 2)
> cat("Overall average: ", overall_avg)
Overall average:  5.17
>
> group_avgs <- round(tapply(Organic$Score, Organic$Food, mean), 2)
> cat("Group averages:")
Group averages:
> cat("Comfort: ", group_avgs[1], " Control: ", group_avgs[2], " Organic: ",
group_avgs[3])
Comfort:  4.89  Control:  5.08  Organic:  5.58
>
> group_vars <- round(tapply(Organic$Score, Organic$Food, var), 2)
> cat("Group variances: ", group_vars)
Group variances:  0.33 0.39 0.35
> cat("Comfort: ", group_vars[1], " Control: ", group_vars[2], " Organic: ",
group_vars[3])
Comfort:  0.33  Control:  0.39  Organic:  0.35
```

(ii)

```
> # 4ii: Get SSB, SSE, SST
> n <- nrow(Organic)
> group_n <- tapply(Organic$Score, Organic$Food, length)
>
> SSB <- sum(group_n * (group_avgs - overall_avg)^2)
> cat("SSB: ", round(SSB, 2))
SSB:  5.25
>
> SSE <- sum((group_avgs - 1) * group_vars)
> cat("SSE: ", round(SSE, 2))
SSE:  4.48
```

```
>
> SST <- SSB + SSE
> cat("SST: ", round(SST, 2))
SST:  9.73
```

(iii)

```
> # 4iii: Anova table
> anova <- aov(Score ~ Food, data = Organic)
> summary(anova)
            Df Sum Sq Mean Sq F value  Pr(>F)   
Food         2   5.33  2.6649   7.512 0.00124 **
Residuals   59  20.93  0.3547                   
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

(iv)

4 iv)

$R^2 = \frac{SSB}{SST} = \frac{5.25}{26.24} \approx 0.2$ of morality score variation is based on food group

Problem 5

(i)

5 i)

$H_0: \mu_1 = \frac{\mu_2+\mu_3}{2}$, $H_a: \mu_1 > \frac{\mu_2+\mu_3}{2}$

$c = (1, -0.5, -0.5) \Rightarrow \psi = (1)\mu_1 + (-0.5)\mu_2 + (-0.5)\mu_3$

(ii)

```
> # 5ii: Get testing statistics, df, pval, conclude on contrast at alpha4 = 0.1
> Ctl_n <- length(Ctl_sc)
> Com_n <- length(Com_sc)
> Org_n <- length(Org_sc)
>
> Ctl_mean <- mean(Ctl_sc)
> Com_mean <- mean(Com_sc)
> Org_mean <- mean(Org_sc)
>
> Ctl_var <- var(Ctl_sc)
> Com_var <- var(Com_sc)
> Org_var <- var(Org_sc)
>
> # get contrast w/ c = (1, -0.5, -0.5)
> contrast = Ctl_mean - 0.5*Com_mean - 0.5*Org_mean
```

```
>
> contrast_stderr <- sqrt((Ctl_var/Ctl_n) + (0.5^2 * (Com_var/Com_n)) + (0.5^2
* (Org_var/Org_n)))
>
> t <- contrast / contrast_stderr
> df <- min(Ctl_n - 1, Com_n - 1, Org_n - 1)
> p <- pt(t, df = df, lower.tail = FALSE)
> round(c(contrast = contrast, se = contrast_stderr, t = t, df = df, p = p), 2)
contrast       se        t       df        p
   -0.15     0.17    -0.92    19.00     0.82
```

5ii)

$p = 0.82 > \alpha = 0.1 \Rightarrow$ fail to reject Ho

$\Rightarrow$ not enough evidence to say control morality score > average of organic & comfort

Problem 6

(i)

```
> # 6i: Get testing statistic, df, pval of each test
> library(agricolae)
>
> # stats, params, means, comparison
> LSD_false <- LSD.test(anova, "Food", p.adj = "none", alpha = 0.1,
group=FALSE)
> print(LSD_false$statistics)
```

MSerror <dbl>	Df <int>	Mean <dbl>	CV <dbl>
0.3547435	59	5.174839	11.5096

```
> print(LSD_false$parameters)
```

test <chr>	p.ajusted <chr>	name.t <chr>	ntr <int>	alpha <dbl>
Fisher-LSD	none	Food	3	0.1

```
> print(LSD_false$means)
```

	Score <dbl>	std <dbl>	r <int>	se <dbl>	LCL <dbl>	UCL <dbl>	Min <dbl>	Max <dbl>	Q25 <dbl>	Q50 <dbl>	Q75 <dbl>
Comfort	4.887273	0.5729139	22	0.1269831	4.675072	5.099473	3.67	6.00	4.5425	4.750	5.1700
Control	5.082500	0.6216690	20	0.1331810	4.859942	5.305058	3.83	6.17	4.7900	5.330	5.3725
Organic	5.583500	0.5935644	20	0.1331810	5.360942	5.806058	4.67	6.33	5.0000	5.585	6.1700

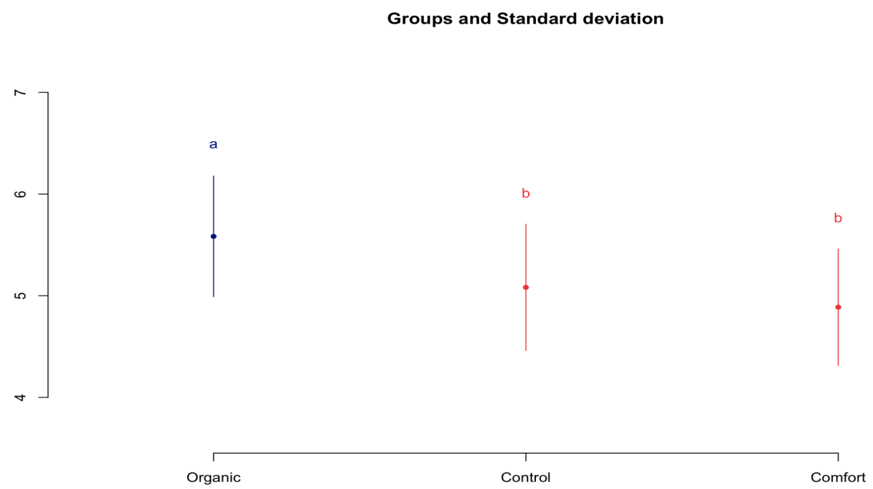
```
> print(LSD_false$comparison)
```

	difference	pvalue	signif.	LCL	UCL
	<dbl>	<dbl>	<chr>	<dbl>	<dbl>
Comfort - Control	-0.1952273	0.2930		-0.5027351	0.1122805
Comfort - Organic	-0.6962273	0.0004	***	-1.0037351	-0.3887195
Control - Organic	-0.5010000	0.0100	**	-0.8157443	-0.1862557

```
> # gets the groups
> LSD_true <- LSD.test(anova, "Food", p.adj = "none", alpha = 0.1, group=TRUE)
> print(LSD_true$groups)
```

	Score	groups
	<dbl>	<chr>
Organic	5.583500	a
Control	5.082500	b
Comfort	4.887273	b

```
> plot(LSD_true , variation ="SD")
```



(ii)

6ii)

Comfort - Control $p = 0.29 > \alpha_s = 0.1$

$\Rightarrow$ Fail to reject H_0

$\Rightarrow$ not enough evidence to show significant difference

Comfort - Organic $p = 0.0004 > \alpha_s = 0.1$

$\Rightarrow$ Reject H_0

$\Rightarrow$ There fore there's sufficient evidence for significant difference

Control - Organic $p = 0.01 > \alpha_s = 0.1$

$\Rightarrow$ Reject H_0

$\Rightarrow$ There fore significantly different

(iii)

6iii)

Compared to control & comfort, and made obvious by the visualization, the organic group's morality score is significantly higher.

We also see that there isn't much difference with the control & comfort scores, so from these we can conclude that there is justification for organic food to be associated w/ higher morality scoring.