# Lab #11: Continuous Variables (2 sample) Key

**1) a.** Type I Error is the false rejection of a true null. Probability = alpha ($\alpha$).
Type II Error is the false retention of a false null. Probability = beta ($\beta$).
Correct Decision I occurs when we fail to reject a true null. Probability = 1-$\alpha$.
Correct Decision II occurs when we reject a false null. Probability = 1-$\beta$. This probability is also known as the power of the statistical test. Power is the ability of a test to find a difference when there is one.

**b.** Factors that influence power include:
1. Alpha ($\alpha$). Alpha and beta are inversely related. In other words, as one increases, the other decreases (i.e., $\alpha \times \beta = K$). Thus, all other things being equal, using an alpha of .05 will result in a more powerful test than using an alpha of .01.
2. Sample Size (N). The bigger the sample (i.e., the more work we do), the more powerful the test.
3. Type of Test. Metric tests (as compared to nonparametric tests) are generally more powerful due to assumptions that are more restrictive.
4. Variability. Generally speaking, variability in the sample and/or population results in a less powerful test.
5. Test Directionality. One-tailed tests have the potential to be more powerful than two-tailed tests.
6. Robustness of the Effect. For example: Six beers are more likely to influence reaction time than one beer.

**c**. They are inversely related. As one increases the other will decrease.

**2) 1. Research Question**
Does caffeine affect running speed?

**2. Hypotheses**

| | Symbols | Words |
|---|---|---|
| $H_O$ | $\mu_1=\mu_2$ | Caffeine does not effect running speed. |
| $H_A$ | $\mu_1\neq\mu_2$ | Caffeine does effect running speed. |

**3. Assumptions**
1. $H_o$
2. Subjects chosen randomly.
3. DV is normally distributed in the population.
4. Groups are independent.
5. Homogeneity of variance.

**4. Decision Rules**
Alpha = .05 with a two-tailed test and df=$N_1+N_2-2$= 12+12-2 =22, $t_{crit}$=2.074

If $t_{obs} \leq$ -2.074or $t_{obs} \geq 2.074$, then reject $H_O$.
If $t_{obs} >$ -2.074 and $t_{obs} <$ 2.074, then do not reject $H_O$.

**5. Computation**

| Subject | Caffeine | $C^2$ | No Caffeine | $NC^2$ |
|---|---|---|---|---|
| 1 | 6.2 | 38.44 | 5.1 | 26.01 |
| 2 | 5.3 | 28.09 | 5.1 | 26.01 |
| 3 | 6.1 | 37.21 | 6.0 | 36.00 |
| 4 | 7.8 | 60.84 | 7.3 | 53.29 |
| 5 | 5.1 | 26.01 | 6.8 | 46.24 |
| 6 | 6.0 | 36.00 | 6.9 | 47.61 |
| 7 | 7.1 | 50.41 | 7.0 | 49.00 |
| 8 | 5.5 | 30.25 | 5.4 | 29.16 |
| 9 | 6.3 | 39.69 | 7.4 | 54.76 |
| 10 | 6.2 | 38.44 | 5.7 | 32.49 |
| 11 | 6.1 | 37.21 | 6.1 | 37.21 |
| 12 | 5.8 | 33.64 | 6.3 | 39.69 |
| $\sum$ | 73.5 | 456.23 | 75.1 | 477.47 |
| **N** | 12 | | 12 | |
| $\bar{X}$ | 6.12 | | 6.26 | |

$$s_1^2 = \frac{N\sum X^2 - \left(\sum X\right)^2}{N(N-1)} = \frac{12 \times 456.23 - 73.5^2}{12(12-1)} = \frac{5474.76 - 5402.25}{12(11)} = \frac{72.51}{132} = .5493$$

$$s_2^2 = \frac{N\sum X^2 - \left(\sum X\right)^2}{N(N-1)} = \frac{12 \times 477.47 - 75.1^2}{12(12-1)} = \frac{5729.64 - 5640.01}{12(11)} = \frac{89.63}{132} = .6790$$

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\left(\frac{(N_1-1)S_1^2 + (N_2-1)S_2^2}{N_1 + N_2 - 2}\right)\left(\frac{1}{N_1} + \frac{1}{N_2}\right)}}$$

$$t = \frac{6.125 - 6.258}{\sqrt{\left(\frac{(12-1).5493 + (12-1).679}{12+12-2}\right)\left(\frac{1}{12} + \frac{1}{12}\right)}}$$

$$t = \frac{\text{-0.133}}{\sqrt{\left(\frac{(11).5493 + (11).679}{22}\right)\left(\frac{2}{12}\right)}} = \frac{\text{-0.133}}{\sqrt{\left(\frac{6.0423 + 7.469}{22}\right)\left(\frac{2}{12}\right)}} = \frac{\text{-0.133}}{\sqrt{\left(\frac{13.5113}{22}\right)\left(\frac{1}{6}\right)}}$$

$$t = \frac{\text{-0.133}}{\sqrt{(0.61415)\left(\frac{1}{6}\right)}} = \frac{\text{-0.133}}{\sqrt{(0.61415)\left(\frac{1}{6}\right)}} = \frac{\text{-0.133}}{\sqrt{0.1024}} = \frac{\text{-0.133}}{.3199} = \text{-0.4157}$$

**6. Decision**

Since -.4157 $t_{obs}$ > -2.074, we fail to reject $H_O$. Therefore, we conclude that caffeine has no effect on running speed.

**3) 1. Research Question**

Do multiplication and division skills differ?

**2. Hypotheses**

| | Symbols | Words |
|---|---|---|
| $H_O$ | $\mu_1=\mu_2$ | There is no difference in math skills. |
| $H_A$ | $\mu_1\neq\mu_2$ | There is a difference in math skills. |

**3. Assumptions**

1. $H_o$
2. Subjects chosen randomly from the population.
3. DV is normally distributed in the population.
4. Scores of the two conditions are correlated.

**4. Decision Rules**

Using 6 subjects, with alpha=.05, two-tailed test, df=N-1=5, $t_{crit}$=2.571.
If $t_{obs} \leq$ -2.571 or $t_{obs} \geq$ 2.571, then reject $H_O$.
If $t_{obs}$ > -2.571 and $t_{obs}$ < 2.571, then do not reject $H_O$.

**5. Computation**

First we describe the data. In other words, we need to compute the means. While we are at it, we might as well compute the difference scores and their squares.

| Subject | X (multip.) | Y (division) | D | $D^2$ |
|---|---|---|---|---|
| 1 | 6 | 5 | 1 | 1 |
| 2 | 6 | 8 | -2 | 4 |
| 3 | 8 | 9 | -1 | 1 |
| 4 | 8 | 9 | -1 | 1 |
| 5 | 9 | 9 | 0 | 0 |
| 6 | 10 | 10 | 0 | 0 |
| | $\bar{X} = 7.83$ | $\bar{X} = 8.33$ | $\sum D$=-3 | $\sum D^2$=7 |

$$t = \frac{\sum D}{\sqrt{\frac{N\sum D^2 - (\sum D)^2}{N-1}}} = \frac{-3}{\sqrt{\frac{6*7-(-3)^2}{6-1}}} = \frac{-3}{\sqrt{\frac{42-9}{5}}}$$

$$t = \frac{-3}{\sqrt{\frac{33}{5}}} = \frac{-3}{\sqrt{6.6}} = \frac{-3}{2.569} = -1.168$$

**6. Decision**

Since -1.168 ($t_{obs}$) <2.571 and > -2.571 ($t_{crit}$), we fail to reject $H_o$. In other words, we conclude that multiplication and division skills do not significantly differ.

**4)** C

**5)** D

**6)** A

**7)** B

**8)** B