

Professor Notes About the “2-Sample t-Test” Homework

- Make sure that you explicitly define what your subscripts mean, especially if you use “1” and “2”.
- Make sure that you provide evidence for the characteristics of when to perform the 2-sample t-test (i.e., explain how you know that there is a quantitative variable, two groups or populations, and individuals in the two groups are independent).
- Note in the “Mussels” question that the sample size is so small that the assumption is that the sample distributions must be normal; “not strongly skewed” is not adequate with this small sample size.
- Note in the “Mussels” question that if you decide to use `Summarize()` to get the sample means then do NOT set `digits=1` because this rounds the means to too few significant digits. In other words, make sure to take note of the scale that the measurements were made on when rounding. Note that `digits=3` would be more appropriate.

Commitment to Adult Animals

1. $\alpha = 0.01$.
2. $H_0 : \mu_{did} = \mu_{didnot}$ (or $\mu_{did} - \mu_{didnot} = 0$) and H_A is $\mu_{did} > \mu_{didnot}$ (or $\mu_{did} - \mu_{didnot} > 0$), where did μ is the mean commitment level, did corresponds to the “did evacuate” group, and $didnot$ corresponds to the “did not evacuate”.
3. A two-sample t-test is required because a quantitative variable (commitment level score) was measured on two groups (“did evacuate” and “did not evacuate”) that were **IN**dependent (no connection between individuals that did and those that did not evacuate their pets).
4. The data appear to be part of a voluntary response observational study without clear randomization.
5. The assumptions are met because the two groups appear to be independent, the sample size ($n_{did} + n_{didnot} = 241$) is > 40 and we were told that the p-value for Levene’s test of the homogeneity of variance test is “large” (i.e., > 0.01) so that it appears that the variances between groups are equal. Therefore, the test statistic computed below should reasonably follow a t-distribution with $n_{did} + n_{didnot} - 2 = 239$ df.
6. The statistic is $\bar{x}_{did} - \bar{x}_{didnot} = 7.694 - 6.640 = 1.054$. The pooled sample variance is,

$$s_p^2 = \frac{(116 - 1)3.410^2 + (125 - 1)3.102^2}{116 + 125 - 2} = 10.58749$$

The standard error of the statistic is,

$$SE_{\bar{x}_{did} - \bar{x}_{didnot}} = \sqrt{10.58749 \left(\frac{1}{116} + \frac{1}{125} \right)} = 0.4194894$$

7. The t test statistic is $\frac{1.054 - 0}{0.4194894} = 2.513$ with $116 + 125 - 2 = 239$ df.
8. The p-value is $p = 0.0063$.
9. The H_0 is rejected because the p-value $< \alpha = 0.01$.
10. The average commitment to animals was significantly greater for those people that did evacuate their pets as compared to those people that did not evacuate their pets.
11. The 99% lower bound is $1.054 - 2.342051 * 0.419 = 0.073$. One is 99% confident that the mean level of commitment for those that evacuated their pets is at least 0.073 greater than those that did not evacuate their pets.

Methyl Mercury in Mussels

1. $\alpha = 0.05$.
2. $H_0 : \mu_i = \mu_r$ (or $\mu_i - \mu_r = 0$) and H_A is $\mu_i \neq \mu_r$ (or $\mu_i - \mu_r \neq 0$), where μ is the mean methyl mercury level, i corresponds to the “impacted” group, and r corresponds to the “reference” group.
3. A two-sample t-test is required because quantitative variable (methyl mercury level) was measured on two groups (“impacted” and “reference” sites) that were **IN**dependent (no connection between sites at the two locations).
4. The data appear to be part of an observational study without clear randomization.
5. The assumptions are not quite met but we will continue anyway. The two groups appear to be independent. The variances appear to be equal because the p-value from the Levene’s test is “large” (i.e., $p = 0.3595 > 0.05$; Table 1). The sample size ($n_i + n_r = 13$) is not > 15 and there is not enough data to make useful histograms. Therefore, the test statistic computed below may not follow a t-distribution with $n_c + n_d - 2 = 11$ df.

Table 1. Levene’s test results for testing equal variances among impacted and reference groups.

	Df	F value	Pr(>F)
group	1	0.9144	0.3595
	11		

6. The statistic is $\bar{x}_c - \bar{x}_d = 0.0573 - 0.0386 = 0.0188$ (Table 2).

Table 2. Two-sample t-test results for testing that the mean mercury levels in mussels differed between the impacted and reference sites.

```
t = 1.5259, df = 11, p-value = 0.1553
95 percent confidence interval:
-0.008301233 0.045825042
sample estimates:
mean in group impacted mean in group reference
0.05733333              0.03857143
```

7. The t test statistic is 1.5259 with 11 df (Table 2).
8. The p-value is $p = 0.1553$ (Table 2).
9. The H_0 is not rejected because the p-value $> \alpha$.
10. Mean methyl mercury levels do not appear to differ between mussels from the impacted and reference sites.

R Appendix.

```
library(NCStats)
( distrib(2.512578,distrib="t",df=239,lower.tail=FALSE) )
( distrib(0.99,distrib="t",df=239,type="q",lower.tail=FALSE) )

setwd('C:/aaaWork/Books/IntroStats/HW/')
df <- read.csv("Mussels.csv")
( m.lt <- levenesTest(mhg~grp,data=df) )
( m.t <- t.test(mhg~grp,data=df,var.equal=TRUE) )
```