BST 203 Lab 2: Non-Parametric Methods
July 26th 2022

Paired Data

- *Sign Test (Not Often Used)*
  - Uses the signs (+ or -) of the differences only
  - For small *n*, use binomial distribution to calculate p-value for *D*

- *Wilcoxon Signed-Rank Test*
  - Nonparametric analogue to the paired t-test
  - Incorporates the magnitude of differences via ranks
  - For small *n,* use Table A.6 to calculate p-value of *T*
  - More powerful than the Sign Test and should be used if given a choice between the two

Nonparametric Tests for Paired Data

	Sign Test	Wilcoxon Signed-Rank Test
H_0	Median difference =0	Median difference =0
Summary of observed data	*D* = # positive differences	*T* = smaller of the sums of the positive and negative ranks
Mean	$\mu_D = n/2$	$\mu_T = \frac{n(n+1)}{4}$
Standard Deviation	$\sigma_D = \sqrt{n/4}$	$\sigma_T = \sqrt{\frac{n(n+1)(2n+1)}{24}}$
Test Statistic	$z_+ = \frac{D-\mu_D}{\sigma_D}$	$z_T = \frac{T-\mu_T}{\sigma_T}$
Distribution of test Statistic (large n)	Standard Normal	Standard Normal

Independent Data

- Wilcoxon Rank Sum Test
  - Nonparametric equivalent to the two-sample t-test
  - Assumes that the distributions of the two populations have the same shape
  - If *n* is small, use table A.7 to calculate p-values for *W*

Nonparametric Tests for Independent Data

	Wilcoxon Rank Sum Test
H_0	$\text{median}_1 = \text{median}_2$
Summary of observed data	*W* = smaller of the sums of the ranks in the two samples
Mean	$\mu_W = \frac{n_S(n_S+n_L+1)}{2}$
Standard Deviation	$\sigma_W = \sqrt{\frac{n_S n_L(n_S+n_L+1)}{12}}$
Test Statistic	$z_W = \frac{W-\mu_W}{\sigma_W}$
Distribution of test Statistic (large n)	Standard Normal

Example

1. A crossover trial was conducted to test the ability to perform simple puzzle assembly under varying conditions. Eight total subjects were recruited and subjected to two rounds of puzzle building. In the "normal" round, subjects were allowed to construct the puzzle in peace. In the "stress" round, subjects were told they would receive a mild shock three minutes after the start of the experiment and in 30 second intervals after that. Systolic blood pressure was recorded under each condition. The dataset `lab2a.dta` on the course website contains each subject's maximum blood pressure under both conditions (the variable `normal` contains max SBP under the normal condition and the variable `stress` contains max SBP under the stress condition).

- What type of data? Are the data *independent* or *dependent*? What parametric and nonparametric tests are available for this type of data?

- Open the data set `lab2a`. Generate a new variable that is the difference in SBP under each condition.
  `generate diff = normal - stress`

- Create a histogram of the differences. Do they look normally distributed?
  `hist diff, freq`

- What type of statistical test is most appropriate for this data and why?

- What are your null and alternative hypotheses?

- Perform the test with `STATA` (Drop down menu: *Statistics/Summaries,tables,&tests/Nonparametric tests of hypotheses/Wilcoxon matched-pairs signed-rank test*)

```
. signrank normal=stress

Wilcoxon signed-rank test

        sign |      obs   sum ranks    expected
-------------+---------------------------------
    positive |        1         4.5        17.5
    negative |        6        30.5        17.5
        zero |        1           1           1
-------------+---------------------------------
         all |        8          36          36

unadjusted variance       51.00
adjustment for ties       -0.13
adjustment for zeros      -0.25
                     ----------
adjusted variance         50.63

Ho: normal = stress
             z =  -1.827
    Prob > |z| =   0.0677
```

- What is the value of your test statistic? Using the `STATA` output, how could you have calculated it by hand? (Note: the mean and variance of the `STATA` output adjusts for ties)

- What is the p-value of your test?

- Draw a conclusion.

2. In an effort to assess to adequacy of the legal blood-alcohol level for operating a vehicle, the state has decided to perform a randomized trial to test the effect of alcohol on reaction time. The study authors believe the legal limit may need to be lowered (though they will not let this guide their analysis of course). Nineteen total subjects were randomized to either the placebo group or the alcohol group with ten subjects in the placebo and 9 in the alcohol. Subjects in the alcohol group consumed two alcoholic beverages while subjects in the placebo group consumed two similar tasting but non-alcoholic beverages. The average reaction time in seconds to a series of simulated driving tests was calculated and can be found for each subject in the dataset `lab2b.dta`. The variable `react` contains the reaction time in seconds and the variable `group` lists the groups.

- What type of data? Are the data *independent* or *dependent*? What parametric and nonparametric tests are available for this type of data?

- Open the data set `lab2b.dta` which can be found on the course website under the lab data section.
- Create boxplots of the reaction times for each group. Do they look normally distributed?
  `graph box react, over(group)`

- What type of statistical test is most appropriate for this data and why?

- What are your null and alternative hypotheses?

- Perform the test with STATA.

```
. sort group
. ranksum react, by(group)

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

       group |      obs    rank sum    expected
-------------+---------------------------------
     alcohol |        9         122          90
     placebo |       10          68         100
-------------+---------------------------------
    combined |       19         190         190

unadjusted variance      150.00
adjustment for ties        0.00
                         ----------
adjusted variance        150.00

Ho: react(group==alcohol) = react(group==placebo)
              z =   2.613
    Prob > |z| =   0.0090
```

- What is the value of your test statistic? Using the STATA output, how could you have calculated it by hand?

- What is the p-value of your test?

- Draw a conclusion.

3. We will perform a Kruskal-Wallis Test on the 2010 world cup dataset (`lab1.dta`) from Lab 1.

- Open the data set `lab1.dta` which can be found on the course website under the lab data section.
- What type of statistical test is most appropriate for this data and why?

- What are your null and alternative hypotheses?

- Perform the test with `STATA`.

```
. kwallis logpasses, by(position)

Kruskal-Wallis equality-of-populations rank test

  +---------------------------+
  |   position | Obs | Rank Sum |
  |------------+-----+----------|
  |   Defender | 134 | 25558.00 |
  |    Forward |  77 |  9301.50 |
  | Midfielder | 139 | 26565.50 |
  +---------------------------+

chi-squared =    28.854 with 2 d.f.
probability =     0.0001

chi-squared with ties =    28.857 with 2 d.f.
probability =     0.0001
```

- What is the value of your test statistic provided by `STATA` ? How does it compare with the one-way ANOVA p-value that you calculated yesterday?

- What is the p-value of your test?

- Draw a conclusion.

4. **(On Your Own)** Suppose that you are interested in examining the effects of the transition from fetal to postnatal circulation among premature infants. For each of the 14 healthy newborns, respiratory rate is measure at two different times – once when the infant is fewer than 15 days old and again when he or she is more than 25 days old.

Subject	***Time 1***	***Time 2***	
1	62	46	
2	35	42	
3	38	40	
4	80	42	
5	48	36	
6	48	46	
7	64	45	
8	26	40	
9	48	42	
10	27	40	
11	43	46	
12	67	31	
13	52	44	
14	88	48	

- Using the sign test, evaluate the null hypothesis that the median difference in respiratory rates for the two times is equal to 0.

- Evaluate the same hypothesis with the Wilcoxon signed-rank test using the fact that the sum of the positive ranks is 78.5 while the sum of the negative ranks is -26.5.

- Do you reach the same conclusion in each case? Why might your conclusions not be the same?

`STATA Tips:` Nonparametric tests

To perform the nonparametric tests, you must open the data or enter it into the Data Editor. All of the tests are contained under the *Statistics/Summaries, tables, & tests/Nonparametric tests of hypotheses* menu. Note that the Mann-Whitney test is another name for the Wilcoxon rank sum test.