SAS 5.3 T-test and nonparametric comparison

A simple hypothesis testing problem is to compare some statistics in two groups. When certain assumptions are met, the popular t-test is used to compare means. When these assumptions are not met, there are several nonparametric methods that can be used.

1. T-test: Test difference between two group means

Students are randomly assigned to a control or treatment group (where a drug is administered). Their response time to a stimulus is then measured. The times are as follows:

Control	Treatment
80	100
93	103
83	104
89	99
98	102

Do the treatment scores come from a population whose mean is different from the mean of the population from which the control scores were drawn?

There are some assumptions that should be met before we can apply this test. First, the two groups must be independent. This is ensured by out method of random assignment. Second, the theoretical distribution of sampling means should be normally distributed (this is ensured if the sample size is sufficiently large).

```
DATA RESPONSE;
INPUT GROUP $ TIME;
DATALINES;
C 80
C 93
C 83
C 89
C 98
T 100
T 103
T 104
T 99
T 102
;
PROC TTEST DATA=RESPONSE; TITLE
      'T-test Example'; Class
      GROUP;
      VAR TIME;
RUN;
```

Proc TTEST uses a CLASS statement to identify the independent variable—the variable that identifies the two groups of subjects. In our case, the variable GROUP has values of C and T.

Var identifies the dependent variables. In our case, Time. When more than one dependent variable is listed, a separate t-test is computed for each dependent variable in the list

Output:

Method	Variances	DF	t Value	Pr > |t|
Pooled	Equal	8	-3.83	0.0050
Satterthwaite	Unequal	4.6412	-3.83	0.0141

Equality of Variances

Method	Num DF	Den DF	F Value	Pr > F
Folded F	4	4	12.40	0.0318

There are two sets of t-value. One is valid if we have equal variances, the other if we have unequal variances. You will usually find these values very close unless the variances differ widely. The bottom line gives us the probability that variances are unequal due to chance.

If the probability is small (say less than 0.05), then we reject the hypothesis that the variances are equal, We than use the t-value and probability labeled Unequal. If the value greater than 0.05, we use the t-value and probability for equal variances.

In this example, we look at the end of the t-test output and see the F ratio is 12.4, 0.0318<0.05, we may therefore decide to use t value appropriate for groups with unequal variances.

```
PROC univariate DATA=RESPONSE normal; TITLE
'T-test Example'; Class GROUP;
VAR TIME;
 RUN;
 PROC TTEST DATA=RESPONSE; TITLE
       'T-test Example'; Class
       GROUP;
       VAR TIME;
 RUN;
```

2. Two Independent Samples: Distribution Free Tests

There are times when the assumptions for using a t-test are not met. One common problem is that the data are not normally distributed, and your sample size is small. Another common problem is that the data values may only represent ordered categories. We need a nonparametric test to analyze differences in central tendencies for ordinal data. For very small samples, nonparametric tests are often more appropriate since assumptions concerning distributions are difficult to determine.

Wilcoxon rank-sum test for two samples

Consider the following experiment. We have two groups, A and B. Group B has been treated with a drug to prevent tumor formation. Both groups are exposed to a chemical that encourages tumor growth. The masses (in grams) of tumors in groups A and B are:

A: 3.1 2.2 1.7 2.7 2.5

B: 0.0 0.0 1.0 2.3

Wilcoxon test first put all the data(group A and B) in increasing order:

Masses	0	0	1	1.7	2.2	2.3	2.5	2.7	3.1
group	B	B	B	A	A	B	A	A	A
rank	1.5	1.5	3	4	5	6	7	8	9

The sums of ranks for the As and Bs are then computed:
SUM RANKS A=4+5+7+8+9=33
SUM RANKS B=1.5+1.5+3+6=12

If there were smaller tumors in group B, we would expect the Bs to be at the lower end of the rank ordering and therefore have a smaller sum of ranks than the As.

```
DATA TUMOR;
      INPUT GROUP $ MASS @@;
DATALINES;
A 3.1 A 2.2 A 1.7 A 2.7 A 2.5
B 0.0 B 0.0 B 1.0 B 2.3
;
PROC NPAR1WAY DATA=TUMOR WILCOXON;
      TITLE 'NONPARAMETRIC TEST TO COMPARE TUMOR MASSES';
      CLASS GROUP;
      VAR MASS;
      EXACT WILCOXON;
RUN;
```

The double trailing @ signs allow us to place data for several observations on one line.

PROC NPARIWAY performs the nonparametric tests.
The option WILCOXON requests the Wilcoxon rank-sum test.
The CLASS and VAR statements are identical to the CLASS and VAR statements of the t-test procedure.
The EXACT statement causes the program to compute exact p-values(in addition to the asymptotic approximations usually computed) for the tests listed after this statement. We suggest that you include the EXACT statement when you have relatively small sample sizes.

Output from the NPARIWAY procedure follows:

Wilcoxon Scores (Rank Sums) for Variable MASS
Classified by Variable GROUP

GROUP	N	Sum of Scores	Expected Under H0	Std Dev Under H0	Mean Score
A	5	33.0	25.0	4.065437	6.60
B	4	12.0	20.0	4.065437	3.00

Average scores were used for ties.

Wilcoxon Two-Sample Test

Statistic (S)	12.0000
Normal Approximation	
Z	-1.8448
One-Sided Pr < Z	0.0325
Two-Sided Pr > |Z|	0.0651
t Approximation	
One-Sided Pr < Z	0.0511
Two-Sided Pr > |Z|	0.1023
Exact Test	
One-Sided Pr <= S	0.0317
Two-Sided Pr >= |S - Mean|	0.0635

Z includes a continuity correction of 0.5.

Kruskal-Wallis Test

Chi-Square	3.8723
DF	1
Pr > Chi-Square	0.0491

The sum of ranks for groups A and B are shown, as well as their expected values. The exact two-tailed p-value for this test is 0.0635, which is quite close to the Normal approximation value 0.0651. If our tumor example had been stated as one –tailed test, we could have divided the p-value by 2, giving p=0.0317 for the Wilcoxon test probability. This suggests that the mass values for group A are larger than the mass of values for group B(although the p-value for two sided test is just shy of the magic value of 0.05).