Consider the following anova program and its output. Note that the least significant difference test has more power than the t-test.

```
data ;
input trt $ y @@ ;
datalines ;
A 6    A 0    A 2    A 8   A 11
A 4    A 13   A 1    A 8   A 0
B 0    B 2    B 3    B 1   B 18
B 4    B 14   B 9    B 1   B 9
C 13   C 10   C 18   C 5   C 23
C 12   C 5    C 16   C 1   C 20
;

proc anova ;
model y = trt ;
means trt / lsd ttest ;
```

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	293.60000000	146.80000000	3.98	0.0305
Error	27	995.10000000	36.85555556		
Total	29	1288.70000000			

R-Square	Coeff Var	Root MSE	Y Mean
0.227826	76.846553	6.070878	7.900000

Source	DF	Anova SS	Mean Square	F Value	Pr > F
TRT	2	293.60000000	146.80000000	3.98	0.0305

Mean Response

TRT	N	Mean Y	95% CI MIN	95% CI MAX
A	10	5.300000	1.360937	9.239063
B	10	6.100000	2.160937	10.039063
C	10	12.300000	8.360937	16.239063

Least Significant Difference Test

TRT	TRT	Delta Y	95% CI MIN	95% CI MAX	t Value	Pr > |t|	
A	B	-0.800000	-6.370677	4.770677	-0.29	0.7705	
A	C	-7.000000	-12.570677	-1.429323	-2.58	0.0157	*
B	A	0.800000	-4.770677	6.370677	0.29	0.7705	
B	C	-6.200000	-11.770677	-0.629323	-2.28	0.0305	*
C	A	7.000000	1.429323	12.570677	2.58	0.0157	*
C	B	6.200000	0.629323	11.770677	2.28	0.0305	*

Two Sample t-Test

TRT	TRT	Delta Y	95% CI MIN	95% CI MAX	t Value	Pr > |t|	
A	B	-0.800000	-5.922307	4.322307	-0.33	0.7466	
A	C	-7.000000	-12.664270	-1.335730	-2.60	0.0182	*
B	A	0.800000	-4.322307	5.922307	0.33	0.7466	
B	C	-6.200000	-12.467653	0.067653	-2.08	0.0523	
C	A	7.000000	1.335730	12.664270	2.60	0.0182	*
C	B	6.200000	-0.067653	12.467653	2.08	0.0523	

Let us take a closer look at the mean response table.

Mean Response

TRT	N	Mean Y	95% CI MIN	95% CI MAX
A	10	5.300000	1.360937	9.239063
B	10	6.100000	2.160937	10.039063
C	10	12.300000	8.360937	16.239063

Recall that the confidence interval for a treatment mean is

$$\bar{y} \pm t(1 - \alpha/2, \text{dfe}) \times \text{SE}, \quad \text{SE} = \sqrt{\frac{\text{MSE}}{n}}$$

where SE is standard error and MSE (mean square error) is estimated model variance. From the analysis of variance table at the top of the output we have

Source	DF	Sum of Squares	Mean Square
Error	27	995.10000000	36.85555556

Hence

$$\text{dfe} = 27, \quad \text{MSE} = 36.8556$$

The confidence interval for the mean of treatment A can be checked by typing the following into R.

```
ybar = 5.3
n = 10
MSE = 36.8556
dfe = 27
alpha = 0.05
SE = sqrt(MSE / n)
t = qt(1 - alpha/2, dfe) * SE
ybar - t
ybar + t
```

R prints the following results.

```
[1] 1.360934
[1] 9.239066
```

The R results match the mean response table for treatment A.

TRT	N	Mean Y	95% CI MIN	95% CI MAX
A	10	5.300000	1.360937	9.239063

Let us take a closer look at the first line of the least significant difference table.

Least Significant Difference Test

TRT	TRT	Delta Y	95% CI MIN	95% CI MAX	t Value	Pr > |t|
A	B	-0.800000	-6.370677	4.770677	-0.29	0.7705

The least significant difference of two treatment means $\bar{y}_A$ and $\bar{y}_B$ is

$$\text{LSD} = t(1-\alpha/2, \text{dfe}) \times \text{SE}, \quad \text{SE} = \sqrt{\text{MSE} \times \left(\frac{1}{n_A} + \frac{1}{n_B}\right)}$$

The corresponding confidence interval is

$$(\bar{y}_A - \bar{y}_B) \pm \text{LSD}$$

The confidence interval in the LSD table can be checked by typing the following into R.

```
ybarA = 5.3
ybarB = 6.1
nA = 10
nB = 10
MSE = 36.8556
dfe = 27
alpha = 0.05
SE = sqrt(MSE * (1/nA + 1/nB))
LSD = qt(1 - alpha/2, dfe) * SE
ybarA - ybarB - LSD
ybarA - ybarB + LSD
```

R prints the following results.

```
[1] -6.37068
[1] 4.77068
```

The R results match the confidence interval in the LSD table.

TRT	TRT	Delta Y	95% CI MIN	95% CI MAX	t Value	Pr > |t|
A	B	-0.800000	-6.370677	4.770677	-0.29	0.7705

Let us take a closer look at the first line of the t-test table.

```
                              Two Sample t-Test

 TRT    TRT      Delta Y    95% CI MIN    95% CI MAX    t Value    Pr > |t|
 A      B      -0.800000     -5.922307      4.322307      -0.33      0.7466
```

The t-test confidence interval is

$$(\bar{y}_A - \bar{y}_B) \pm t(1 - \alpha/2, \text{dfe}) \times \text{SE}$$

where

$$\text{SE} = \sqrt{\frac{\sum(y_A - \bar{y}_A)^2 + \sum(y_B - \bar{y}_B)^2}{\text{dfe}} \times \left(\frac{1}{n_A} + \frac{1}{n_B}\right)}$$

and

$$\text{dfe} = n_A + n_B - 2$$

The confidence interval can be checked by typing the following into R.

```
yA = c(6,0,2,8,11,4,13,1,8,0)
yB = c(0,2,3,1,18,4,14,9,1,9)
nA = length(yA)
nB = length(yB)
dfe = nA + nB - 2
SSE = var(yA) * (nA - 1) + var(yB) * (nB - 1)
MSE = SSE / dfe
SE = sqrt(MSE * (1/nA + 1/nB))
alpha = 0.05
t = qt(1 - alpha/2, dfe) * SE
mean(yA) - mean(yB) - t
mean(yA) - mean(yB) + t
```

R prints the following result which matches the above t-test table.

```
[1] -5.922307
[1] 4.322307
```

R's t-test function gives the same result.

```
t.test(yA,yB,var.equal=TRUE)

Two Sample t-test

data:  yA and yB
t = -0.32812, df = 18, p-value = 0.7466
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -5.922307  4.322307
```