Each participant contributes a pretest and a posttest: participants and time of measurement are crossed and therefore time is a within-subjects factor

```
DATA;
INPUT PRE 1-2 .1 POST 3-4 .1;
D = POST - PRE;
CARDS;
2625
4657
8993
5567
1915
6278
4647
5659
6973
6670
proc print double;
proc means maxdec=3;
var pre post;
```

```
proc means n mean std t prt maxdec=3 lclm uclm;
var D;
proc corr;
var pre post;
run;
quit;
```

Results of proc print have been edited out .

The MEANS Procedure

The MEANS Procedure

Variable	N	Mean	Std Dev	Minimum	Maximum
PRE	10	5.340	2.054	1.900	8.900
POST	10	5.840	2.388	1.500	9.300

The MEANS Procedure

Analysis Variable : D

N	Mean	Std Dev	t Value	Pr > |t|	Lower 95% CL for Mean	Upper 95% CL for Mean
10	0.500	0.620	2.55	0.0312	0.056	0.944

Note that the variance of D is equal to $\boldsymbol{S_1^2 + S_2^2 - 2S_1S_2r = 2.054^2 + 2.388^2 - 2(2.054)(2.388)(.972)}$, where .972 is the correlation between the pre and post variables.

The CORR Procedure

2 Variables: PRE POST

Simple Statistics

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
PRE	10	5.34000	2.05383	53.40000	1.90000	8.90000
POST	10	5.84000	2.38849	58.40000	1.50000	9.30000

Pearson Correlation Coefficients, N = 10
Prob > |r| under H0: Rho=0

	PRE	POST
PRE	1.00000	0.97223 <.0001
POST	0.97223 <.0001	1.00000

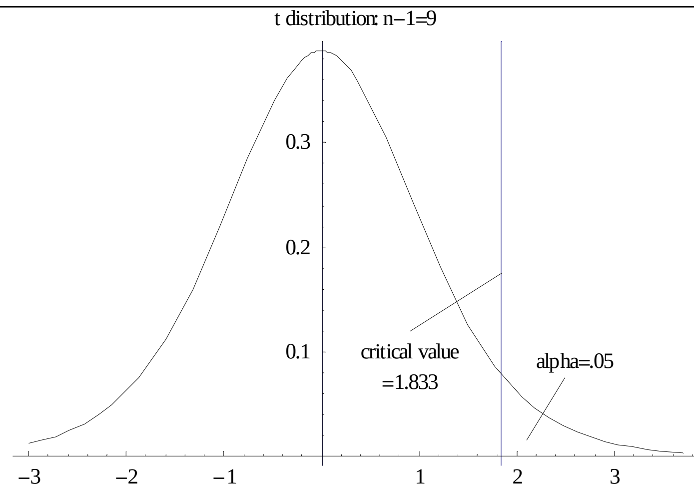
```
*This program computes an approximate
CI for the effect size in a within-
subjects design with two groups.
m2 and m1 are the means for the two
groups
s1 and s2 are the standard deviations
for the two groups
n1 and n2 are the sample sizes for the
two groups
r is the correlation
prob is the confidence level;
data;
m1=5.84;
m2=5.34  ;
s1=2.388  ;
s2=2.054  ;
r= .97223 ;
n=10    ;
prob=.95 ;
v1=s1**2;
v2=s2**2;
s12=s1*s2*r;
se=sqrt((v1+v2-2*s12)/n);
pvar=(v1+v2)/2;
nchat=(m1-m2)/se;
es=(m1-m2)/(sqrt(pvar));
df=n-1;
ncu=TNONCT(nchat,df,(1-prob)/2);
```

```
ncl=TNONCT(nchat,df,1-(1-prob)/2);
ul=se*ncu/(sqrt(pvar));
ll=se*ncl/(sqrt(pvar));
output;
proc print;
title1 'll is the lower limit and ul
is the upper limit';
title2 'of a confidence interval for
the effect size';
var es ll ul ;
run;
quit;
```

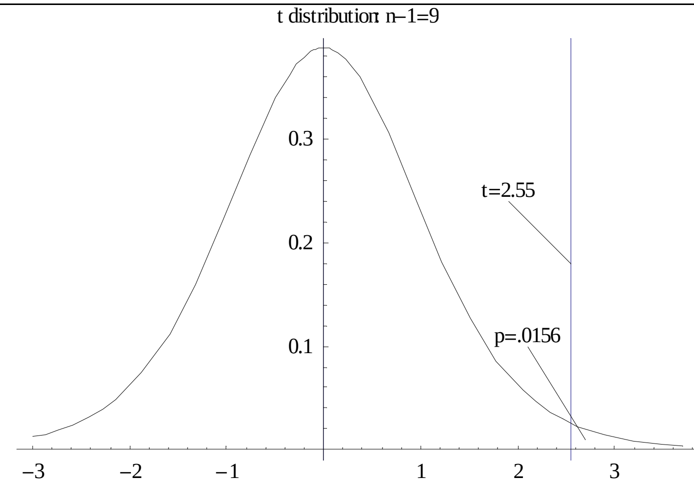
```
ll is the lower limit and ul is the
upper limit of a confidence interval
for the effect size

Obs       es          ll           ul

1      0.22449    0.019549    0.42040
```

	1=Post 2=Pre	$D = Y_1 - Y_2 = Post - Pre$
1.	$H_0 : \mu_1 - \mu_2 = 0$	$H_0 : \mu_D = 0$
	$H_1 : \mu_1 - \mu_2 > 0$	$H_1 : \mu_D > 0$
2.	$t_{\alpha,n-1} = t_{.05,10-1} = 1.833$	
		

	$H_0: \mu_1 - \mu_2 = 0$	$H_0: \mu_D = 0$
	$H_1: \mu_1 - \mu_2 > 0$	$H_1: \mu_D > 0$
3.	$t = \frac{\bar{Y}_1 - \bar{Y}_2}{\sqrt{\frac{S_1^2 + S_2^2 - 2S_1S_2r}{n}}}$ $= \frac{5.84 - 5.34}{\sqrt{\frac{2.054^2 + 2.388^2 - 2(2.054)(2.388)(.972)}{n}}}$ $= 2.55$	$t = \frac{\bar{D}}{\sqrt{\frac{S_D^2}{n}}}$ $t = \frac{.5}{\sqrt{\frac{.620^2}{10}}}$ $= 2.55$

4.	$Prob > \|t\| = .0312$ Sign of $\bar{Y}_1 - \bar{Y}_2$ and hypothesized sign of $\mu_1 - \mu_2$ are the same, so $p = \frac{1}{2}(Prob > \|t\|) = \frac{1}{2}(.0312) = .0156$
	
5.	Reject H_0
6.	We can conclude that the population posttest mean is larger than the population pretest mean

7.	$$\left(\bar{Y}_1 - \bar{Y}_2\right) \pm \left(t_{\alpha/2,\,n-1}\right)\left(\sqrt{\frac{S_1^2 + S_2^2 - 2S_1S_2r}{n}}\right)$$	$$\bar{D} \pm \left(t_{\alpha/2,\,n-1}\right)\left(\sqrt{\frac{S_D^2}{n}}\right)$$
	$\left(5.84 - 5.34\right) \pm$ $\left(2.262\right)\left(\sqrt{\frac{2.054^2 + 2.388^2 - 2\left(2.054\right)\left(2.388\right)\left(.972\right)}{10}}\right)$	$\bar{D} \pm \left(2.262\right)\left(\sqrt{\frac{.620^2}{10}}\right)$
	.057, .944 We are 95% confident that the population mean difference between the posttest and pretest mean is between 1 tenth of a point and 9 tenths of a point. This seems like a narrow range.	

8.	$d \frac{\bar{Y}_1 - \bar{Y}_2}{\sqrt{\frac{S_1^2 + S_2^2}{2}}}$ $= \frac{5.84 - 5.34}{\sqrt{\frac{2.054^2 + 2.388^2}{2}}}$ $= .224$
	$(.02, .42)$ We are 95% confident that Cohen's effect size is between .02 (an almost non-existent effect and .42 (an almost medium effect). The interval for the effect size seems somewhat wide.