A) EQUIVALENCE TEST

Equivalence test (TOST approach) was performed for the following six comparisons:

Independent groups

1. Tilt angles during fixed and free condition
2. Safety margin of Index finger during fixed and free condition
3. Safety margin of Middle finger during fixed and free condition
4. Safety margin of Little finger during fixed and free condition

Dependent groups

5. Ring and little finger normal force during free condition
6. Percentage of normal force shared by ring and little fingers during free condition

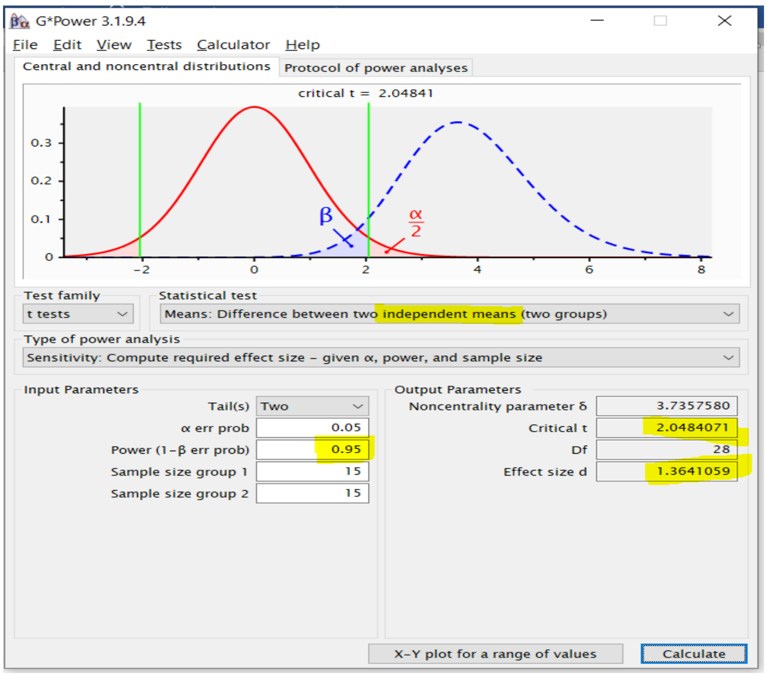
B) SESOI calculation (or equivalence bounds) for Independent groups

(i)For a desired level of statistical power of 95%, with the sample size of 15, alpha =0.05, we get equivalence bounds **in R package as following**.

```
> powerTOSTtwo(alpha=0.05, N=15, statistical_power=0.95)
The equivalence bounds to achieve 95 % power with N = 15 are -1.32 and 1.3
2 .

[1] -1.316293  1.316293
```

(ii)For a desired level of statistical power of 95%, with the sample size of 15, alpha =0.05, we get smallest effect size of interest (d=SESOI) **in GPower as following** (performed for confirmation).

Effect size =1.36 (approximately same as we got in R package)



iii) Formula for equivalence bounds calculation (for independent group) used in R

$$Equivalence\ bounds = \frac{\sqrt{2}\left[qnorm(1-\ \alpha) + qnorm\left[1 - \left(\frac{1-power}{2}\right)\right]\right]}{\sqrt{n}}$$

Above formula for equivalence bounds derived from (Chow et al. 2007)

$$n = \frac{(\sigma_1^2 +\ \sigma_2^2)\left(z_{\alpha/2} +\ z_\beta\right)^2}{\delta^2}$$

$\sigma_1^2 =\ \sigma_2^2 = \sigma$=SD=1 Mean=1

$$\boldsymbol{\delta} = \frac{\sqrt{\mathbf{2}}\left(\boldsymbol{z}_{\alpha/2} +\ \boldsymbol{z}_\beta\right)}{\sqrt{\boldsymbol{n}}}$$

$$\boldsymbol{Equivalence\ bounds\ (d)} = \frac{\sqrt{\mathbf{2}}[\boldsymbol{t}_{0.95} + \boldsymbol{t}_{0.975}]}{\sqrt{\boldsymbol{n}}}$$

$$\boldsymbol{Equivalence\ bounds\ (d)} = \frac{\sqrt{\mathbf{2}}\ [\boldsymbol{t}]}{\sqrt{\boldsymbol{n}}}$$

qnorm is the R function that calculates the inverse c. d. f. of the normal distribution.By providing probability to the qnorm function, it returns associated z score. Alpha=0.05, power=0.95

Z score of $t_{0.95}$=1.645,

95% of the values in a population that is normally distributed with mean 0 and standard deviation 1 will lie below 1.645

Z score of $t_{0.975}$ =1.96

97.5% of the values in a population that is normally distributed with mean 0 and standard deviation 1 will lie below 1.96

n=15, we get d=1.414*(3.606/3.87)= 1.31

t Table

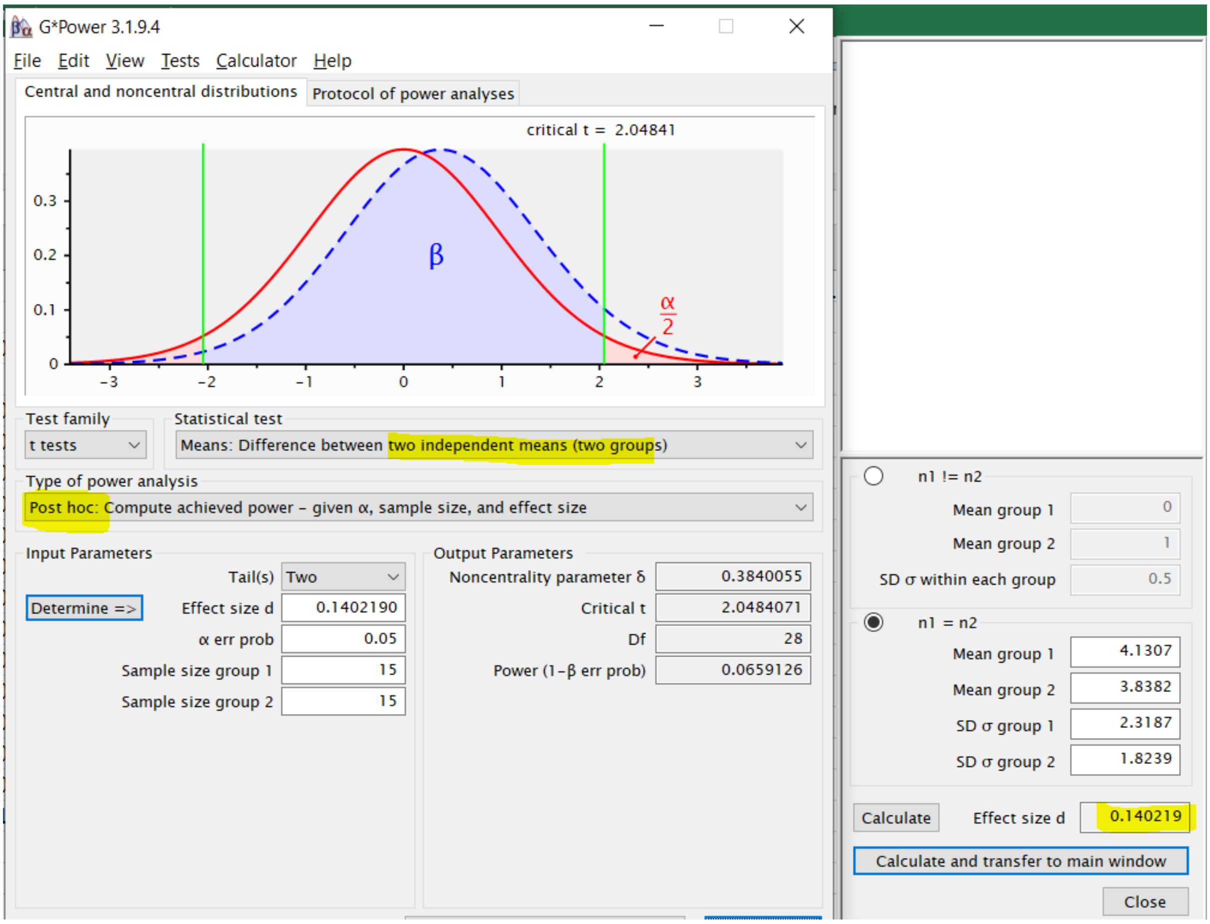
cum. prob	$t_{.50}$	$t_{.75}$	$t_{.80}$	$t_{.85}$	$t_{.90}$	$t_{.95}$	$t_{.975}$	$t_{.99}$	$t_{.995}$	$t_{.999}$	$t_{.9995}$
one-tail	**0.50**	**0.25**	**0.20**	**0.15**	**0.10**	**0.05**	**0.025**	**0.01**	**0.005**	**0.001**	**0.0005**
two-tails	**1.00**	**0.50**	**0.40**	**0.30**	**0.20**	**0.10**	**0.05**	**0.02**	**0.01**	**0.002**	**0.001**
df											
1	0.000	1.000	1.376	1.963	3.078	6.314	12.71	31.82	63.66	318.31	636.62
2	0.000	0.816	1.061	1.386	1.886	2.920	4.303	6.965	9.925	22.327	31.599
3	0.000	0.765	0.978	1.250	1.638	2.353	3.182	4.541	5.841	10.215	12.924
4	0.000	0.741	0.941	1.190	1.533	2.132	2.776	3.747	4.604	7.173	8.610
5	0.000	0.727	0.920	1.156	1.476	2.015	2.571	3.365	4.032	5.893	6.869
6	0.000	0.718	0.906	1.134	1.440	1.943	2.447	3.143	3.707	5.208	5.959
7	0.000	0.711	0.896	1.119	1.415	1.895	2.365	2.998	3.499	4.785	5.408
8	0.000	0.706	0.889	1.108	1.397	1.860	2.306	2.896	3.355	4.501	5.041
9	0.000	0.703	0.883	1.100	1.383	1.833	2.262	2.821	3.250	4.297	4.781
10	0.000	0.700	0.879	1.093	1.372	1.812	2.228	2.764	3.169	4.144	4.587
11	0.000	0.697	0.876	1.088	1.363	1.796	2.201	2.718	3.106	4.025	4.437
12	0.000	0.695	0.873	1.083	1.356	1.782	2.179	2.681	3.055	3.930	4.318
13	0.000	0.694	0.870	1.079	1.350	1.771	2.160	2.650	3.012	3.852	4.221
14	0.000	0.692	0.868	1.076	1.345	1.761	2.145	2.624	2.977	3.787	4.140
15	0.000	0.691	0.866	1.074	1.341	1.753	2.131	2.602	2.947	3.733	4.073
16	0.000	0.690	0.865	1.071	1.337	1.746	2.120	2.583	2.921	3.686	4.015
17	0.000	0.689	0.863	1.069	1.333	1.740	2.110	2.567	2.898	3.646	3.965
18	0.000	0.688	0.862	1.067	1.330	1.734	2.101	2.552	2.878	3.610	3.922
19	0.000	0.688	0.861	1.066	1.328	1.729	2.093	2.539	2.861	3.579	3.883
20	0.000	0.687	0.860	1.064	1.325	1.725	2.086	2.528	2.845	3.552	3.850
21	0.000	0.686	0.859	1.063	1.323	1.721	2.080	2.518	2.831	3.527	3.819
22	0.000	0.686	0.858	1.061	1.321	1.717	2.074	2.508	2.819	3.505	3.792
23	0.000	0.685	0.858	1.060	1.319	1.714	2.069	2.500	2.807	3.485	3.768
24	0.000	0.685	0.857	1.059	1.318	1.711	2.064	2.492	2.797	3.467	3.745
25	0.000	0.684	0.856	1.058	1.316	1.708	2.060	2.485	2.787	3.450	3.725
26	0.000	0.684	0.856	1.058	1.315	1.706	2.056	2.479	2.779	3.435	3.707
27	0.000	0.684	0.855	1.057	1.314	1.703	2.052	2.473	2.771	3.421	3.690
28	0.000	0.683	0.855	1.056	1.313	1.701	2.048	2.467	2.763	3.408	3.674
29	0.000	0.683	0.854	1.055	1.311	1.699	2.045	2.462	2.756	3.396	3.659
30	0.000	0.683	0.854	1.055	1.310	1.697	2.042	2.457	2.750	3.385	3.646
40	0.000	0.681	0.851	1.050	1.303	1.684	2.021	2.423	2.704	3.307	3.551
60	0.000	0.679	0.848	1.045	1.296	1.671	2.000	2.390	2.660	3.232	3.460
80	0.000	0.678	0.846	1.043	1.292	1.664	1.990	2.374	2.639	3.195	3.416
100	0.000	0.677	0.845	1.042	1.290	1.660	1.984	2.364	2.626	3.174	3.390
1000	0.000	0.675	0.842	1.037	1.282	1.646	1.962	2.330	2.581	3.098	3.300
z	0.000	0.674	0.842	1.036	1.282	1.645	1.960	2.326	2.576	3.090	3.291
	0%	50%	60%	70%	80%	90%	95%	98%	99%	99.8%	99.9%
	Confidence Level										

Therefore, -1.31 was taken as lower equivalence bounds and 1.31 taken as upper equivalence bounds for tost comparisons that involved independent groups

iv) Observed effect size calculating formula for independent groups

$$d = \frac{|m_1 - m_2|}{\sqrt{\frac{s_1^2 + s_2^2}{2}}}$$

Observed effect size for tilt angle data from GPower= 0.1402


G*Power 3.1.9.4
File Edit View Tests Calculator Help
Central and noncentral distributions
Protocol of power analyses
critical t = 2.04841
β
α/2
Test family
t tests
Statistical test
Means: Difference between two independent means (two groups)
Type of power analysis
Post hoc: Compute achieved power – given α, sample size, and effect size
Input Parameters
Tail(s) Two
Determine =>
Effect size d 0.1402190
α err prob 0.05
Sample size group 1 15
Sample size group 2 15
Output Parameters
Noncentrality parameter δ 0.3840055
Critical t 2.0484071
Df 28
Power (1–β err prob) 0.0659126
n1 != n2
Mean group 1 0
Mean group 2 1
SD σ within each group 0.5
n1 = n2
Mean group 1 4.1307
Mean group 2 3.8382
SD σ group 1 2.3187
SD σ group 2 1.8239
Calculate
Effect size d 0.140219
Calculate and transfer to main window
Close

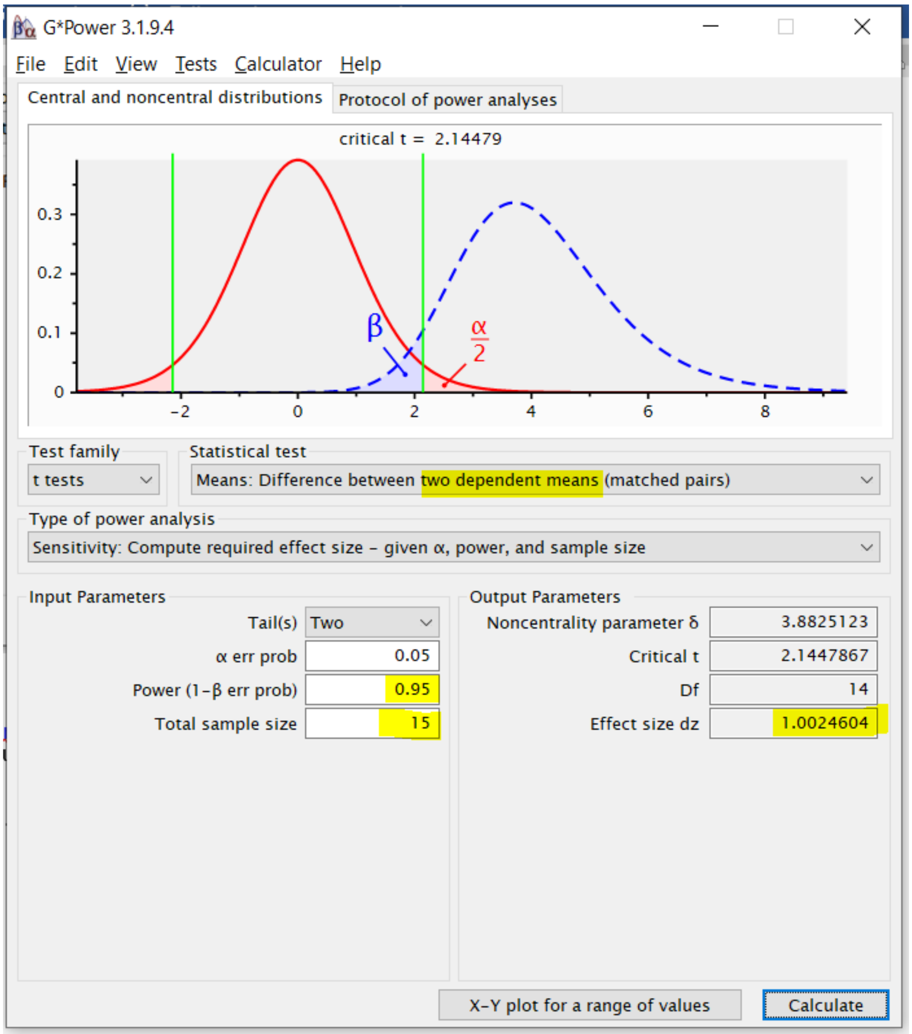
C) SESOI calculation (or equivalence bounds) for dependent groups

(i)For a desired level of statistical power of 95%, with the sample size of 15, alpha =0.05, we get equivalence bounds **in R package as following**.

```
> powerTOSTpaired(alpha=0.05, N=15, statistical_power=0.95)
The equivalence bounds to achieve 95 % power with N = 15 are -0.93 and 0.9
3 .

[1] -0.9307599  0.9307599
```

(ii)For a desired level of statistical power of 95%, with the sample size of 15, alpha =0.05, we get smallest effect size of interest (dz=SESOI) **in GPower as following** (performed for confirmation).

Effect size (equivalence bound) =1.002 (approximately same as we got in R package)



iii) Formula for equivalence bounds calculation (for dependent group)

$$Equivalence\ bounds = \frac{\left[qnorm(1-\ \alpha) + qnorm\left[1 - \left(\frac{1-power}{2}\right)\right]\right]}{\sqrt{n}}$$

$$\boldsymbol{Equivalence\ bounds\ (dz)} = \frac{[\boldsymbol{t_{0.95}} + \boldsymbol{t_{0.975}}]}{\sqrt{\boldsymbol{n}}}$$

$$\boldsymbol{Equivalence\ bounds\ (dz)} = \frac{[\boldsymbol{t}]}{\sqrt{\boldsymbol{n}}}$$

n=15, we get dz=(3.606/3.87)= 0.931

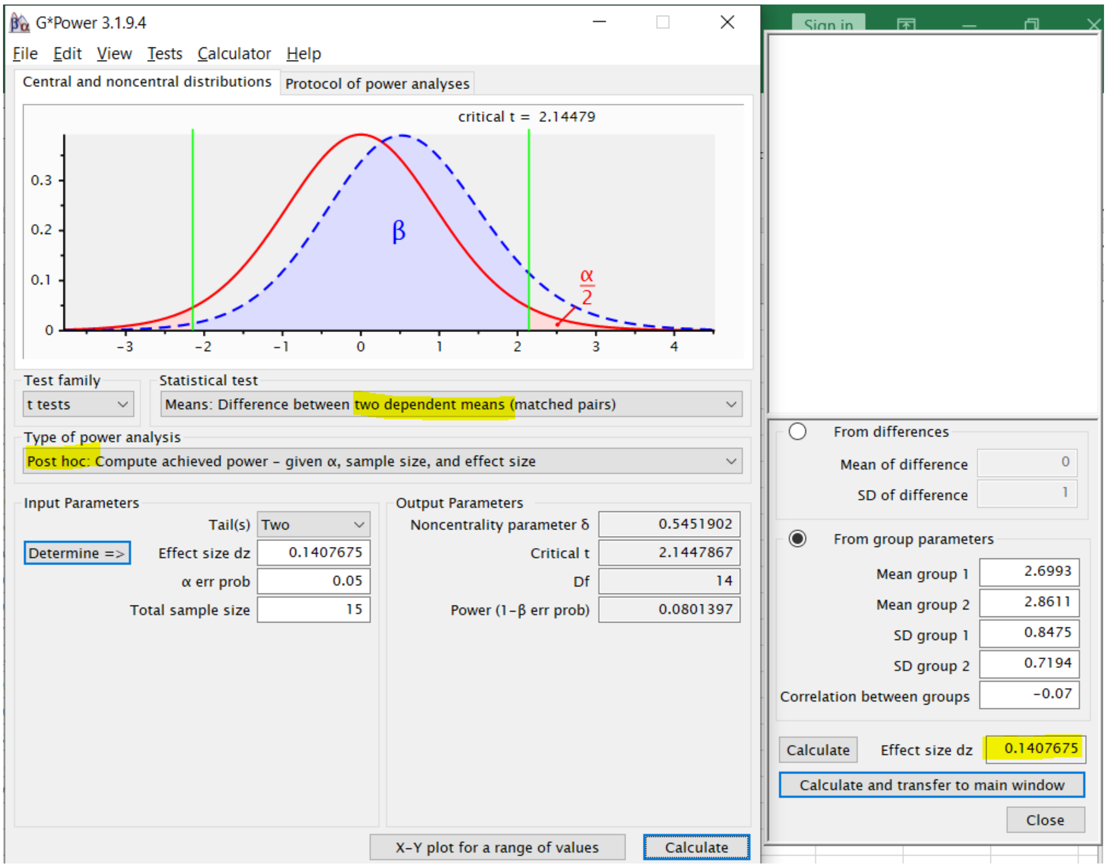
The relationship between Cohen's d and dz is a factor of $\sqrt{2}$
(Lakens,2017)

Therefore, -0.93 was taken as lower equivalence bounds and 0.93 taken as upper equivalence bounds for tost comparisons that involved dependent groups

iv) Observed effect size calculating formula for **dependent groups**

$$d = \frac{|m_1 - m_2|}{\sqrt{s_1^2 + s_2^2 - (2rs_1s_2)}}$$

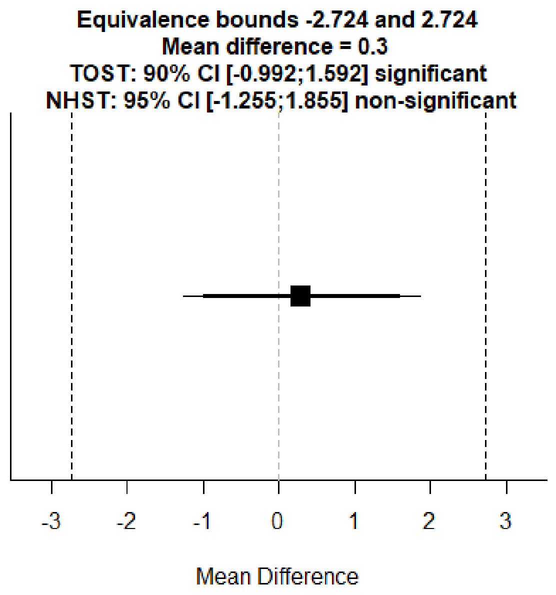
Observed effect size for Ring and little finger normal force data from GPower= 0.1407


G*Power 3.1.9.4
File Edit View Tests Calculator Help
Central and noncentral distributions
Protocol of power analyses
critical t = 2.14479
β
α
2
Test family
t tests
Statistical test
Means: Difference between two dependent means (matched pairs)
Type of power analysis
Post hoc: Compute achieved power – given α, sample size, and effect size
Input Parameters
Tail(s) Two
Determine =>
Effect size dz 0.1407675
α err prob 0.05
Total sample size 15
Output Parameters
Noncentrality parameter δ 0.5451902
Critical t 2.1447867
Df 14
Power (1-β err prob) 0.0801397
X-Y plot for a range of values
Calculate
From differences
Mean of difference 0
SD of difference 1
From group parameters
Mean group 1 2.6993
Mean group 2 2.8611
SD group 1 0.8475
SD group 2 0.7194
Correlation between groups -0.07
Calculate
Effect size dz 0.1407675
Calculate and transfer to main window
Close

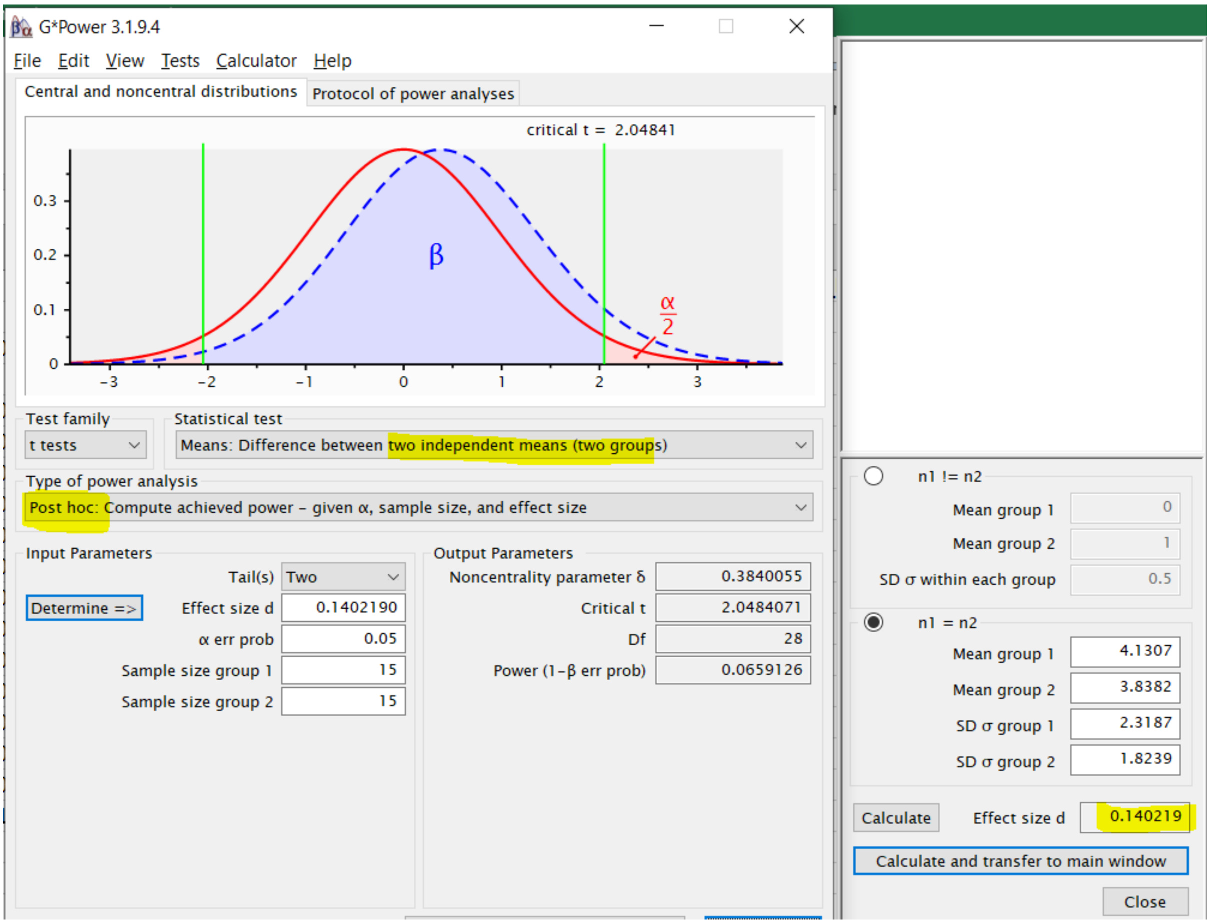
TOST Results from R package

1) Tilt angle data during fixed and free condition

```
> TOSTtwo(m1=4.13,m2=3.83,sd1=2.31,sd2=1.82,n1=15,n2=15,low_eqbound=-1.31,
high_eqbound=1.31,0.05,var.equal=TRUE)
TOST results:
t-value lower bound: 3.98      p-value lower bound: 0.0002
t-value upper bound: -3.19     p-value upper bound: 0.002
degrees of freedom : 28

Equivalence bounds (Cohen's d):
low eqbound: -1.31
high eqbound: 1.31

Equivalence bounds (raw scores):
low eqbound: -2.7241
high eqbound: 2.7241

TOST confidence interval:
lower bound 90% CI: -0.992
upper bound 90% CI:  1.592

NHST confidence interval:
lower bound 95% CI: -1.255
upper bound 95% CI:  1.855

Equivalence Test Result:
The equivalence test was significant, t(28) = -3.192, p = 0.00174, given e
quivalence bounds of -2.724 and 2.724 (on a raw scale) and an alpha of 0.0
5.


Null Hypothesis Test Result:
The null hypothesis test was non-significant, t(28) = 0.395, p = 0.696, gi
ven an alpha of 0.05.


Based on the equivalence test and the null-hypothesis test combined, we ca
n conclude that the observed effect is statistically not different from ze
ro and statistically equivalent to zero.
```

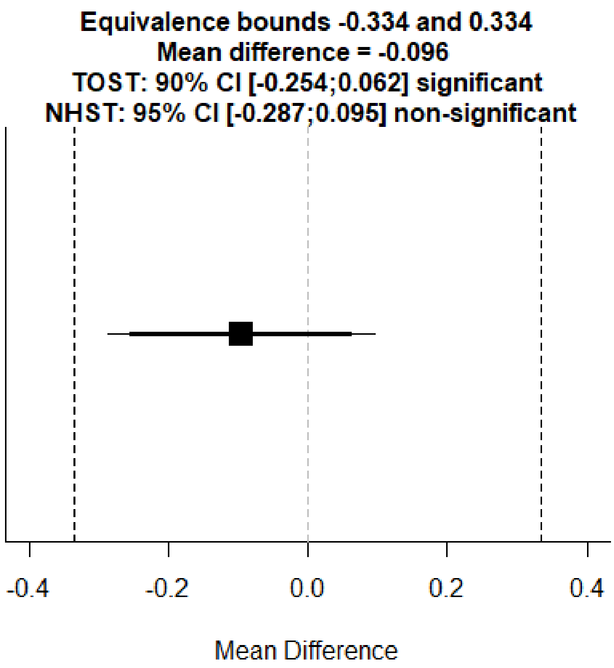


Observed effect size

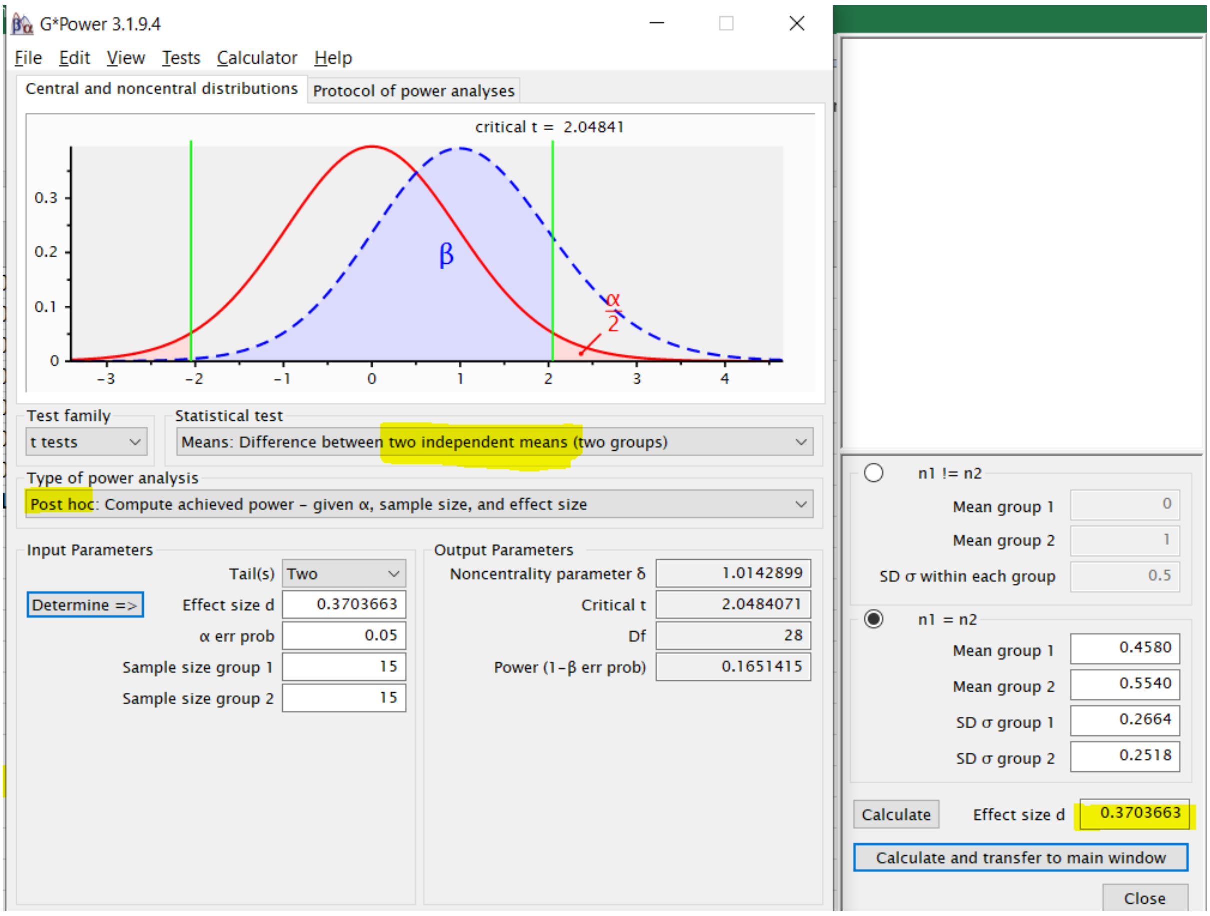


2) SMz_Index_fixed vs SMz_Index_free

```
> TOSTtwo(m1=0.4580, m2=0.5540,sd1=0.26,sd2=0.25,n1=15,n2=15,low_eqbound=-
1.31,high_eqbound=1.31,var.equal=TRUE)
TOST results:
t-value lower bound: 2.56     p-value lower bound: 0.008
t-value upper bound: -4.62    p-value upper bound: 0.00004
degrees of freedom : 28

Equivalence bounds (Cohen's d):
low eqbound: -1.31
high eqbound: 1.31

Equivalence bounds (raw scores):
low eqbound: -0.3341
high eqbound: 0.3341

TOST confidence interval:
lower bound 90% CI: -0.254
upper bound 90% CI:  0.062

NHST confidence interval:
lower bound 95% CI: -0.287
upper bound 95% CI:  0.095

Equivalence Test Result:
The equivalence test was significant, t(28) = 2.557, p = 0.00814, given eq
uivalence bounds of -0.334 and 0.334 (on a raw scale) and an alpha of 0.05
.


Null Hypothesis Test Result:
The null hypothesis test was non-significant, t(28) = -1.031, p = 0.311, g
iven an alpha of 0.05.


Based on the equivalence test and the null-hypothesis test combined, we ca
n conclude that the observed effect is statistically not different from ze
ro and statistically equivalent to zero.
```

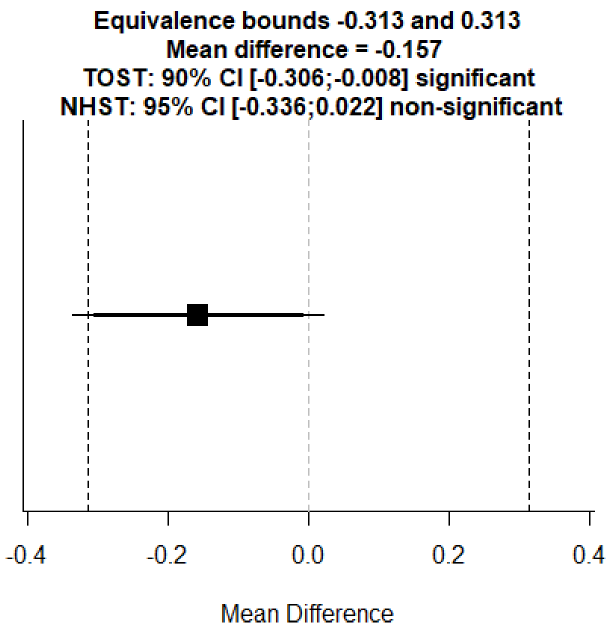


Observed effect size

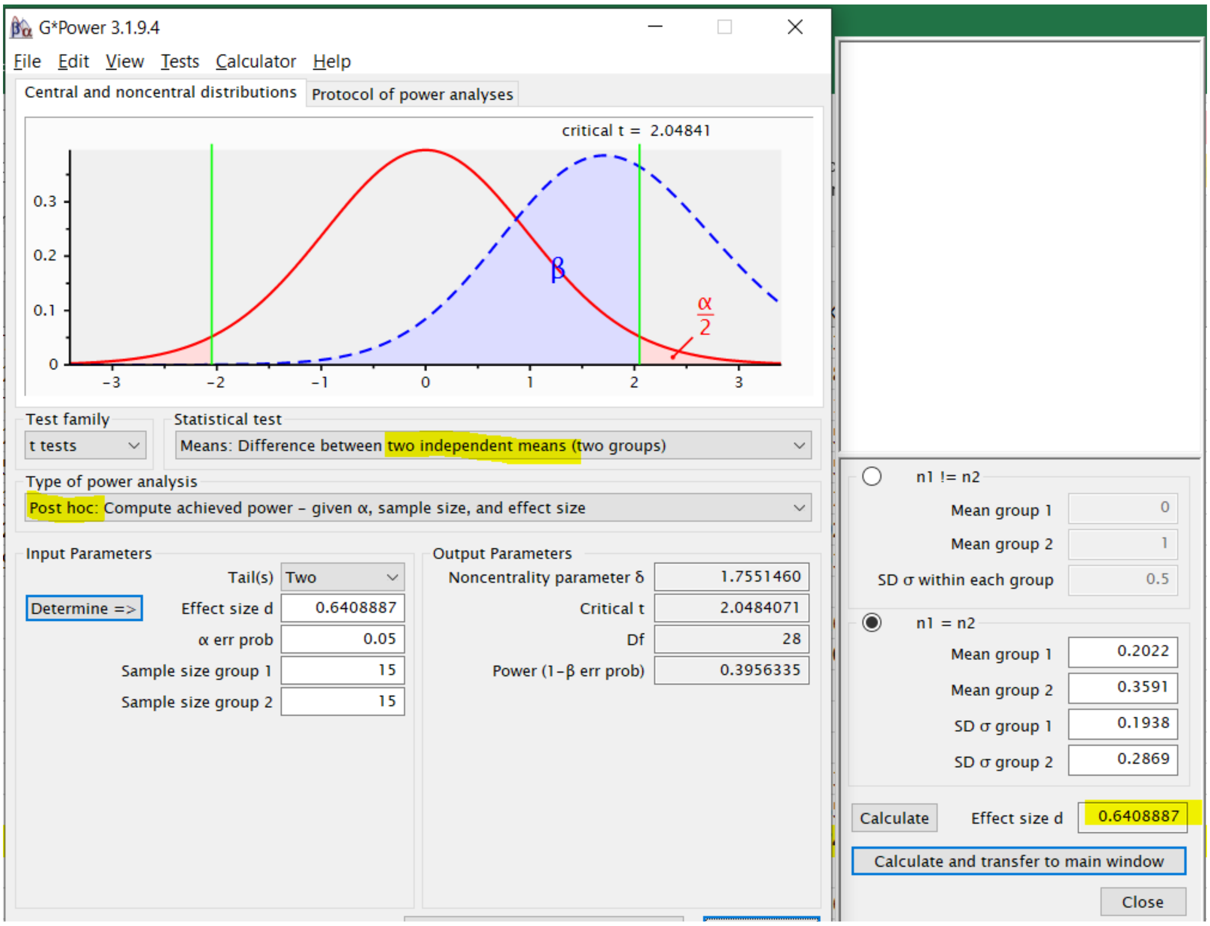


3) SMz_Middle_fixed vs SMz_ Middle_free

```
> TOSTtwo(m1=0.2022, m2=0.3591,sd1=0.19,sd2=0.28,n1=15,n2=15,low_eqbound=-
1.31,high_eqbound=1.31,var.equal=TRUE)
TOST results:
t-value lower bound: 1.79      p-value lower bound: 0.042
t-value upper bound: -5.38     p-value upper bound: 0.000005
degrees of freedom : 28

Equivalence bounds (Cohen's d):
low eqbound: -1.31
high eqbound: 1.31

Equivalence bounds (raw scores):
low eqbound: -0.3134
high eqbound: 0.3134

TOST confidence interval:
lower bound 90% CI: -0.306
upper bound 90% CI:  -0.008

NHST confidence interval:
lower bound 95% CI: -0.336
upper bound 95% CI:  0.022

Equivalence Test Result:
The equivalence test was significant, t(28) = 1.792, p = 0.042, given equi
valence bounds of -0.313 and 0.313 (on a raw scale) and an alpha of 0.05.


Null Hypothesis Test Result:
The null hypothesis test was non-significant, t(28) = -1.796, p = 0.0833,
given an alpha of 0.05.


Based on the equivalence test and the null-hypothesis test combined, we ca
n conclude that the observed effect is statistically not different from ze
ro and statistically equivalent to zero.
```

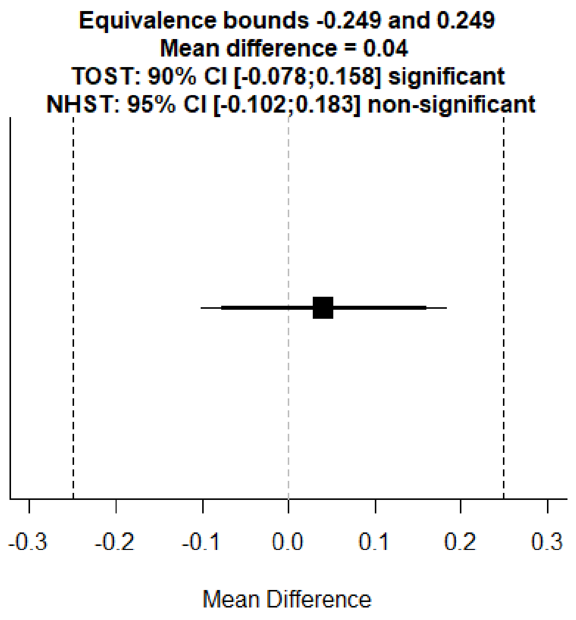


Observed effect size

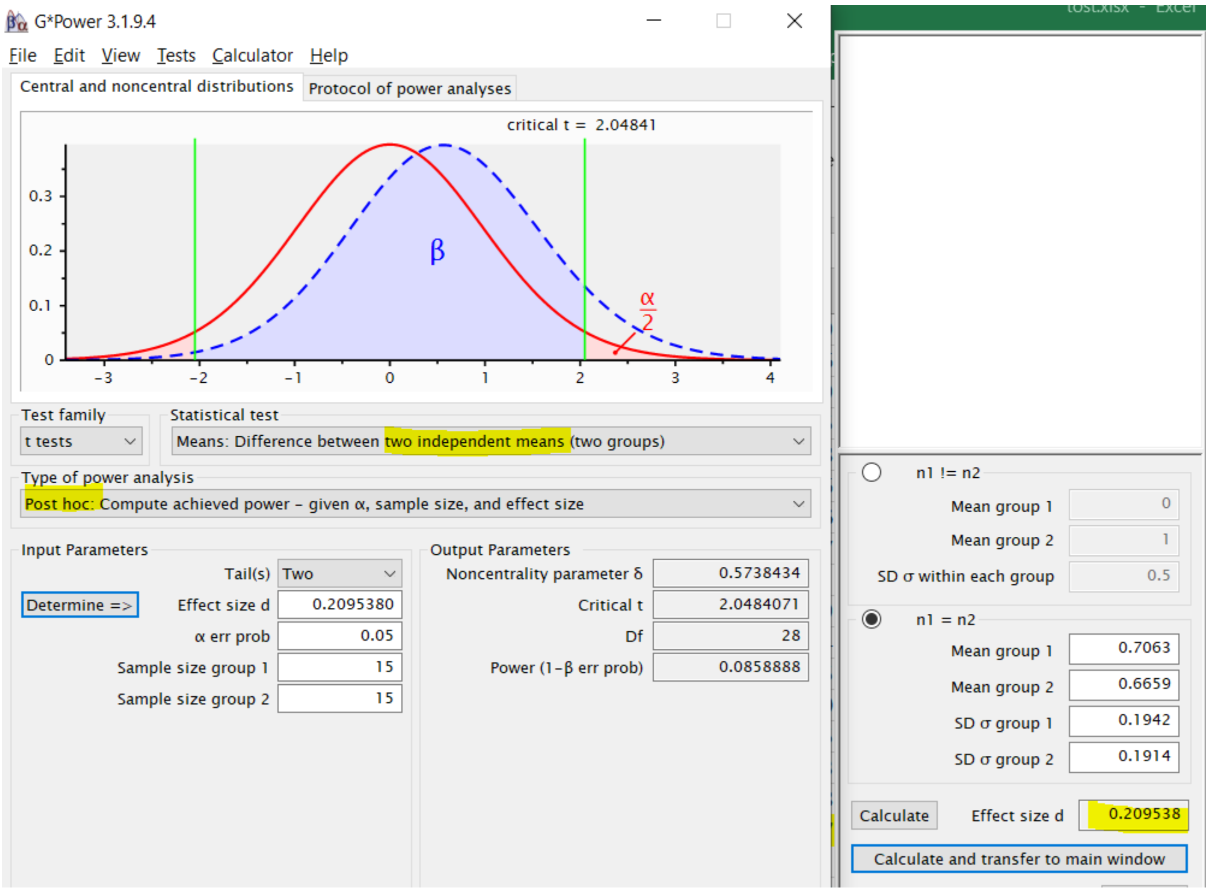


4) SMz_Little_fixed vs SMz_Little_free

```
> TOSTtwo(m1=0.7063, m2=0.6659,sd1=0.19,sd2=0.19,n1=15,n2=15,low_eqbound=-
1.31,high_eqbound=1.31,var.equal=TRUE)
TOST results:
t-value lower bound: 4.17      p-value lower bound: 0.0001
t-value upper bound: -3.01     p-value upper bound: 0.003
degrees of freedom : 28

Equivalence bounds (Cohen's d):
low eqbound: -1.31
high eqbound: 1.31

Equivalence bounds (raw scores):
low eqbound: -0.2489
high eqbound: 0.2489

TOST confidence interval:
lower bound 90% CI: -0.078
upper bound 90% CI:  0.158

NHST confidence interval:
lower bound 95% CI: -0.102
upper bound 95% CI:  0.183

Equivalence Test Result:
The equivalence test was significant, t(28) = -3.005, p = 0.00277, given e
quivalence bounds of -0.249 and 0.249 (on a raw scale) and an alpha of 0.0
5.


Null Hypothesis Test Result:
The null hypothesis test was non-significant, t(28) = 0.582, p = 0.565, gi
ven an alpha of 0.05.


Based on the equivalence test and the null-hypothesis test combined, we ca
n conclude that the observed effect is statistically not different from ze
ro and statistically equivalent to zero.
```

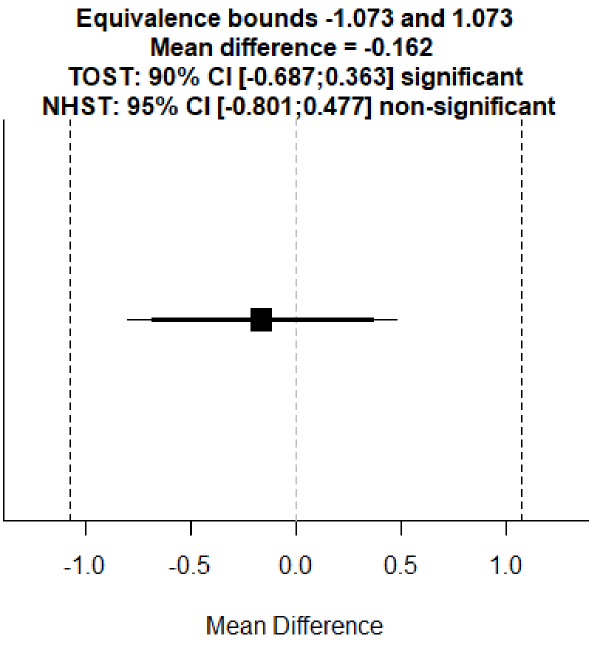


Observed effect size

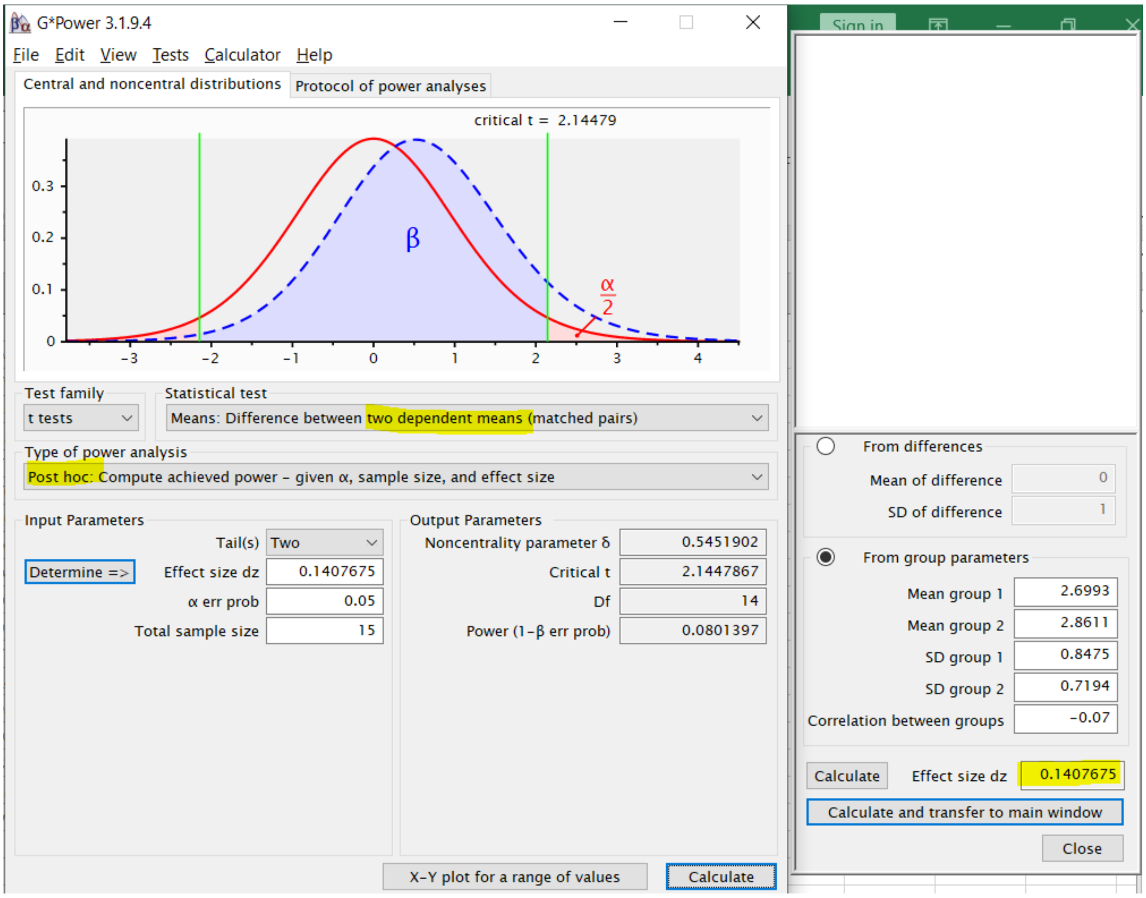


5) Ring and little finger Normal force during free condition

```
> TOSTpaired(n=15,m1=2.6993, m2=2.8611,sd1=0.8475,sd2=0.7194,r12=-0.079,lo
w_eqbound_dz=-0.93,high_eqbound_dz=0.93)
TOST results:
t-value lower bound: 3.06      p-value lower bound: 0.004
t-value upper bound: -4.14     p-value upper bound: 0.0005
degrees of freedom : 14

Equivalence bounds (Cohen's dz):
low eqbound: -0.93
high eqbound: 0.93

Equivalence bounds (raw scores):
low eqbound: -1.0734
high eqbound: 1.0734

TOST confidence interval:
lower bound 90% CI: -0.687
upper bound 90% CI:  0.363

NHST confidence interval:
lower bound 95% CI: -0.801
upper bound 95% CI:  0.477

Equivalence Test Result:
The equivalence test was significant, t(14) = 3.059, p = 0.00425, given eq
uivalence bounds of -1.073 and 1.073 (on a raw scale) and an alpha of 0.05
.


Null Hypothesis Test Result:
The null hypothesis test was non-significant, t(14) = -0.543, p = 0.596, g
iven an alpha of 0.05.


Based on the equivalence test and the null-hypothesis test combined, we ca
n conclude that the observed effect is statistically not different from ze
ro and statistically equivalent to zero.
```

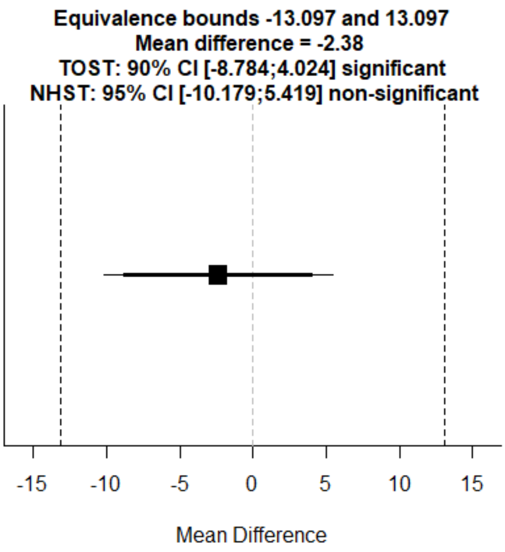


Observed effect size

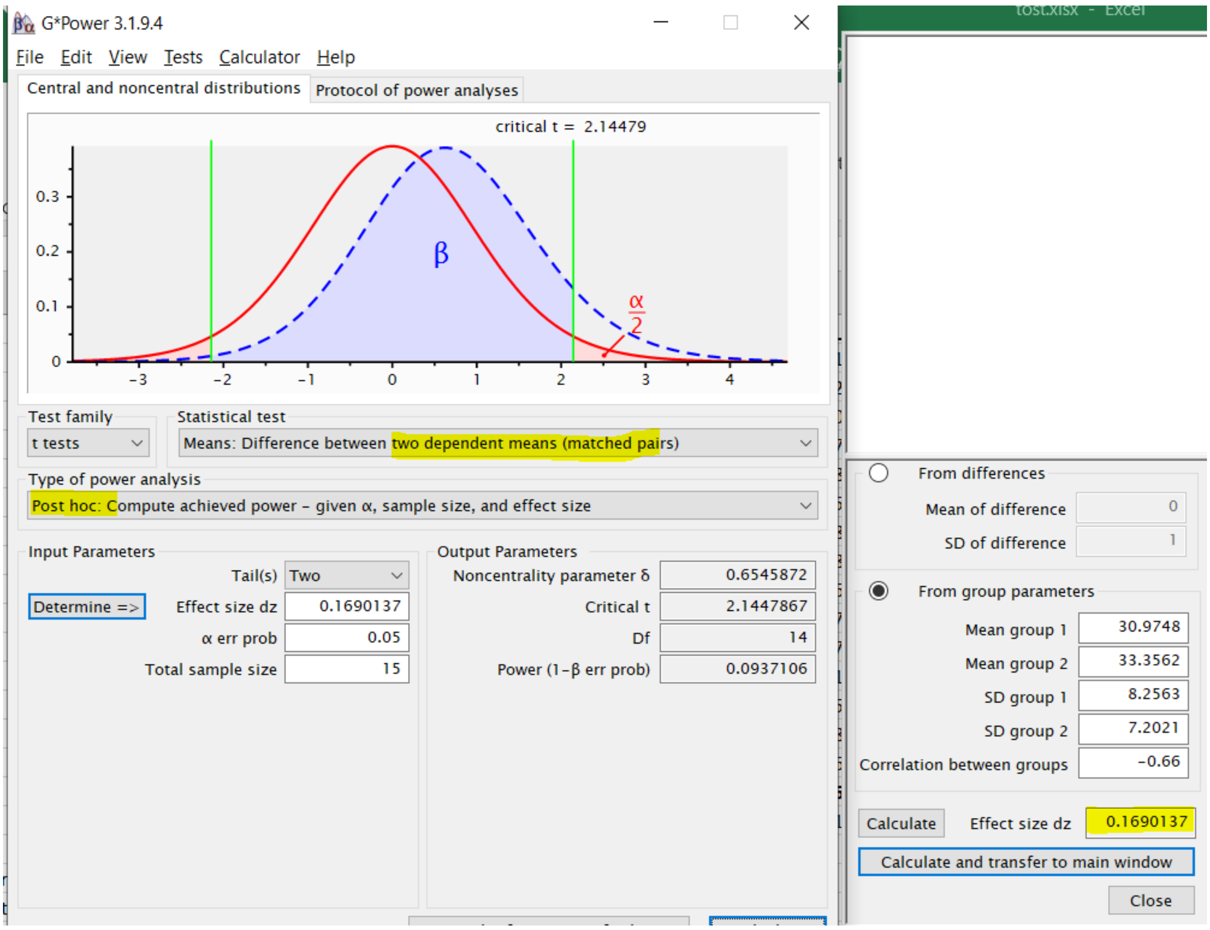


5)% of Ring and little finger Normal force shared during free condition

```
> TOSTpaired(n=15,m1=30.97, m2=33.35,sd1=8.25,sd2=7.20,r12=-0.66,low_eqbou
nd_dz=-0.93,high_eqbound_dz=0.93)
TOST results:
t-value lower bound: 2.95      p-value lower bound: 0.005
t-value upper bound: -4.26     p-value upper bound: 0.0004
degrees of freedom : 14

Equivalence bounds (Cohen's dz):
low eqbound: -0.93
high eqbound: 0.93

Equivalence bounds (raw scores):
low eqbound: -13.0965
high eqbound: 13.0965

TOST confidence interval:
lower bound 90% CI: -8.784
upper bound 90% CI:  4.024

NHST confidence interval:
lower bound 95% CI: -10.179
upper bound 95% CI:  5.419

Equivalence Test Result:
The equivalence test was significant, t(14) = 2.947, p = 0.0053, given equ
ivalence bounds of -13.097 and 13.097 (on a raw scale) and an alpha of 0.0
5.


Null Hypothesis Test Result:
The null hypothesis test was non-significant, t(14) = -0.655, p = 0.523, g
iven an alpha of 0.05.


Based on the equivalence test and the null-hypothesis test combined, we ca
n conclude that the observed effect is statistically not different from ze
ro and statistically equivalent to zero.
```



Observed effect size



SUMMARY

COMPARISON	OBSERVED EFFECT SIZE	STANDARDISED EQUIVALENCE BOUNDS		NULL HYPOTHESIS TEST		TOST TEST		EQUIVALENT (YES/NO)
		LOWER LIMIT	UPPER LIMIT	t values	p values	t values	p values	
Tilt angle (fixed and free conditions)	d= 0.1402	-1.31	1.31	t(28) = 0.395	p = 0.696	t(28) = -3.192	p = 0.00174	Yes
Safety Margin of index (fixed and free conditions)	d= 0.3703	-1.31	1.31	t(28) = -1.031	p = 0.311	t(28) = 2.557	p = 0.00814	Yes
Safety Margin of Middle (fixed and free conditions)	d= 0.6408	-1.31	1.31	t(28) = -1.796	p = 0.0833	t(28) = 1.792	p = 0.042	Yes
Safety Margin of little (fixed and free conditions)	d= 0.2095	-1.31	1.31	t(28) = 0.582	p = 0.565	t(28) = -3.005	p = 0.00277	Yes
R and L Normal force (free condition)	dz=0.1407	-0.93	0.93	t(14) = -0.543	p = 0.596	t(14) = 3.059	p = 0.00425	Yes
% of Normal force shared by R and L (free condition)	dz=0.1690	-0.93	0.93	t(14) = -0.655	p = 0.523	t(14) = 2.947	p = 0.0053	Yes

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