How Effect Size Impacts Sample Size

Note and Disclaimer:

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The following effect size numbers are based on Jacob Cohen's *Statistical Power Analysis for the Behavioral Sciences* (Second Edition, p. 82)

Effect Size	d	r
Small	0.2	0.1
Medium	0.5	0.3
Large	0.8	0.5

Cohen's *d*

Cohen d is used to quantify the size of the difference between two groups, taking into account the variability within each group.

That is, x is categorical variable, whereas y is numerical variable (i.e., Y is on a continuous scale).

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

Pearson *r*

When both x and y are numerical, we need to use pearson correlation coefficient to measure effect size r.

$$r_{xy} = \frac{cov(x,y)}{s_x s_y} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2}}$$

Convert *r* to *d*

$$d = \frac{2r}{\sqrt{1 - r^2}}$$

Convert *d* to *r*

$$r = \frac{d}{\sqrt{4 + d^2}}$$

Effect Size and Sample Size

In general, as the effect size increases, the required sample size decreases, assuming that statistical power (1 - β) and the alpha level (α) are held constant, respectively.

R Code Example 1: t-test

To calculate the needed sample size for a two-sample t-test with a specified power of 0.8, a significance level of 0.05, and an effect size of 0.5, you can use the pwr.t.test function in R.

effect size = 0.50

```
library(pwr)
```

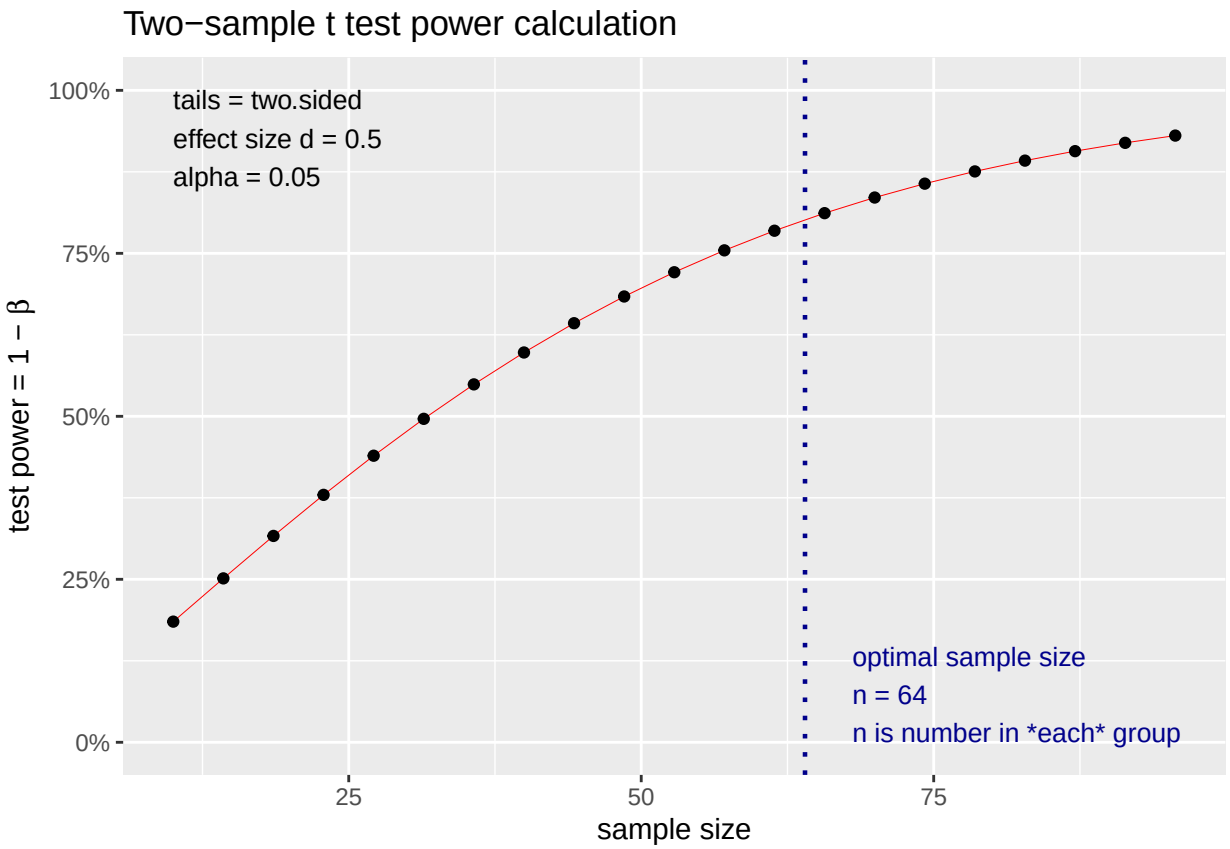
```
## Warning: package 'pwr' was built under R version 4.1.3
```

```
result_1<-pwr.t.test(n=NULL,
           d = 0.5,
           sig.level = 0.05,
           power = 0.80,
           type = "two.sample",
           alternative="two.sided")

print(result_1)
```

```
##
##      Two-sample t test power calculation
##
##               n = 63.76561
##               d = 0.5
##       sig.level = 0.05
##           power = 0.8
##     alternative = two.sided
##
## NOTE: n is number in *each* group
```

```
plot(result_1)
```


Two−sample t test power calculation
tails = two.sided
effect size d = 0.5
alpha = 0.05
optimal sample size
n = 64
n is number in *each* group
100%
75%
50%
25%
0%
test power = 1 − β
25
50
75
sample size

Increasing the effect size from 0.5 to 0.8:

effect size = 0.80

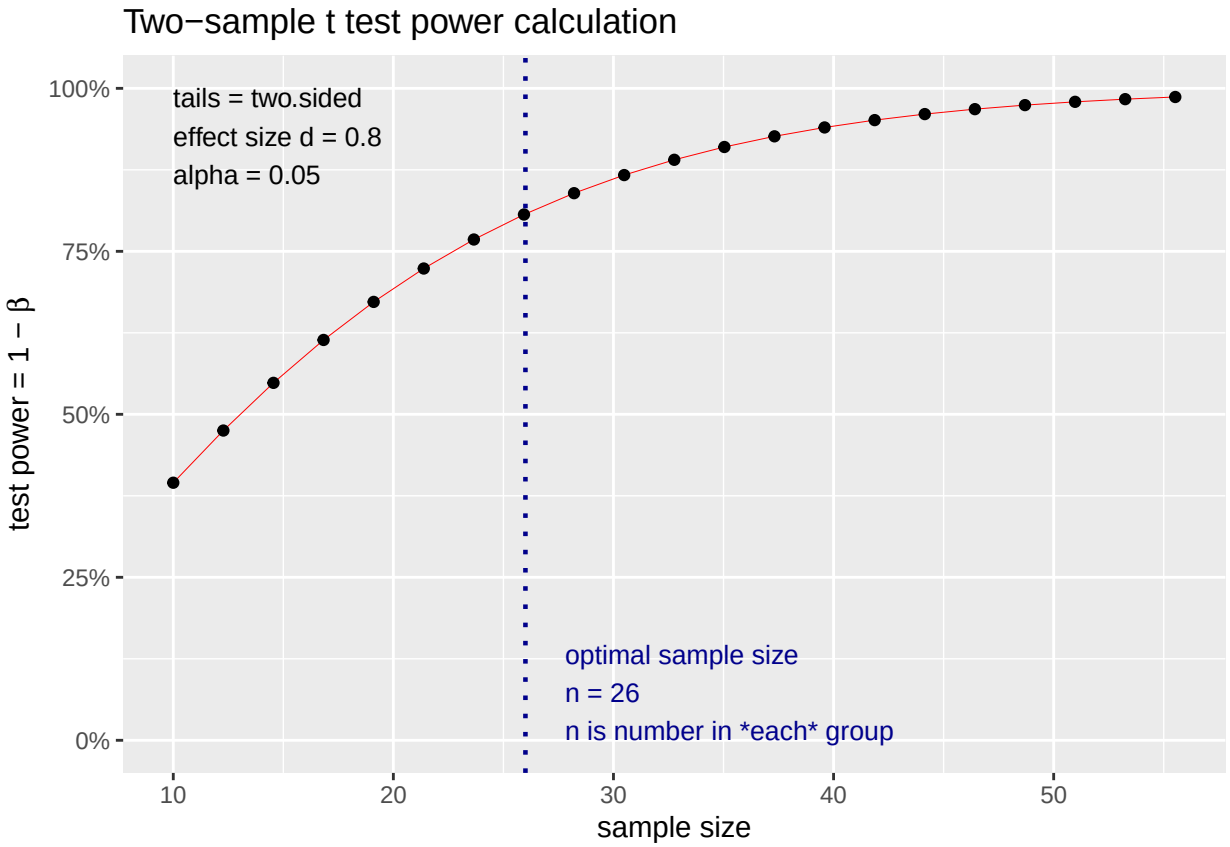
```
library(pwr)

result_2<-pwr.t.test(n=NULL,
           d = 0.8,
           sig.level = 0.05,
           power = 0.80,
           type = "two.sample",
           alternative="two.sided")

print(result_2)
```

```
##
##      Two-sample t test power calculation
##
##               n = 25.52458
##               d = 0.8
##       sig.level = 0.05
##           power = 0.8
##     alternative = two.sided
##
## NOTE: n is number in *each* group
```

```
plot(result_2)
```


Two−sample t test power calculation
tails = two.sided
effect size d = 0.8
alpha = 0.05
optimal sample size
n = 26
n is number in *each* group
test power = 1 − β
100%
75%
50%
25%
0%
10
20
30
40
50
sample size

R Code Example 2: Correlation

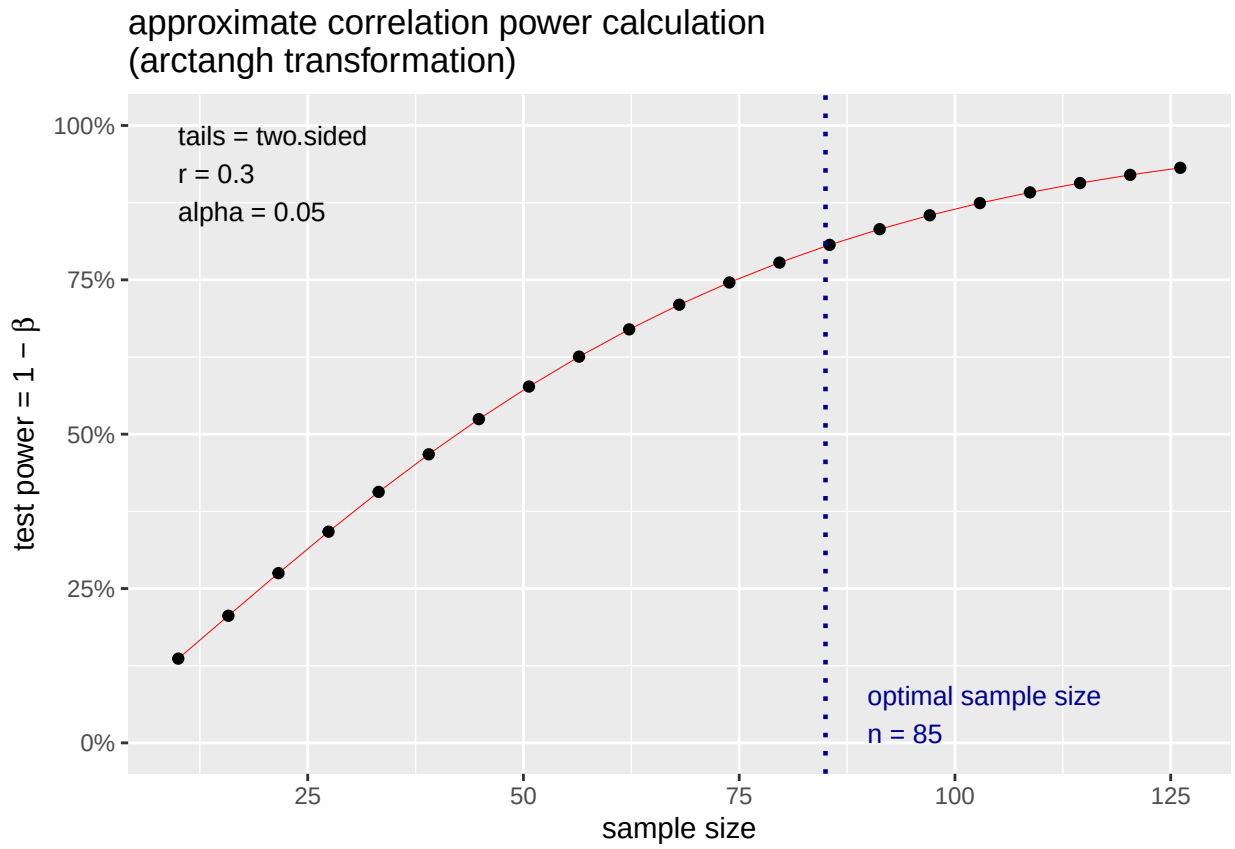
effect size = 0.30

```
result_3<-pwr.r.test(n = NULL,
           r = 0.3,
           sig.level = 0.05,
           power = 0.80,
           alternative = "two.sided")

print(result_3)
```

```
##
##      approximate correlation power calculation (arctangh transformation)
##
##               n = 84.07364
##               r = 0.3
##       sig.level = 0.05
##           power = 0.8
##     alternative = two.sided
```

```
plot(result_3)
```



effect size = 0.50

```
result_4<-pwr.r.test(n = NULL,
           r = 0.5,
           sig.level = 0.05,
           power = 0.80,
           alternative = "two.sided")

print(result_4)
```

```
##
##      approximate correlation power calculation (arctangh transformation)
##
##                n = 28.24841
##                r = 0.5
##        sig.level = 0.05
##            power = 0.8
##      alternative = two.sided
```

```
plot(result_4)
```