**Decision** | $H_0$ is true | $H_0$ is false  
--- | --- | ---  
Fail to reject $H_0$ | $1 - \alpha$ | Type II error: $\beta$  
Reject $H_0$ | Type I error: $\alpha$ | power: $1 - \beta$

**Things that affect power**

<table>
<thead>
<tr>
<th>thing</th>
<th>Pr(Type I error)</th>
<th>effect size</th>
<th>power</th>
</tr>
</thead>
<tbody>
<tr>
<td>increasing effect size</td>
<td>same</td>
<td>increases</td>
<td>increases</td>
</tr>
<tr>
<td>increasing sample Size</td>
<td>same</td>
<td>same</td>
<td>increases</td>
</tr>
<tr>
<td>increasing alpha</td>
<td>increases</td>
<td>same</td>
<td>increases</td>
</tr>
<tr>
<td>two-tailed test</td>
<td>same</td>
<td>same</td>
<td>decreases</td>
</tr>
</tbody>
</table>

1) Shifting normal distributions
2) Power curves
3) Stats excel power calculator
4) Power t test in R

need to know: 4 things sample size $n$, effect size $d$, $\alpha$, one or two-tailed
5) Your advisor asks you to sample 40 balloons and 16 dinosaurs from their populations and measure both their price and their traffic. You calculate that for balloons their price correlates with traffic with 0.72 and for dinosaurs the correlation is 0.88.

Using an alpha value of $\alpha = 0.01$, is the observed correlation for balloons significantly less than for dinosaurs?

- **baloons**
  - $r_1 = 0.72$, $n_1 = 40$
  - $r_2 = 0.88$, $n_2 = 16$

- **dinosaurs**

  $H_0$: $r_1 = r_2$
  $H_A$: $r_1 < r_2$

**Fisher's z**

$$z_1' = \arcsin\left(\frac{1 + r_1}{2}\right) = 0.908$$
$$z_2' = \arcsin\left(\frac{1 + r_2}{2}\right) = 1.376$$

$$z = \frac{z_2' - z_1'}{\sqrt{\frac{1}{n_1-3} + \frac{1}{n_2-3}}} = \frac{1.376 - 0.908}{\sqrt{\frac{1}{37} + \frac{1}{13}}} = 0.3224$$

$$z = 1.45$$

$$p = 0.0732 \approx 0.01$$ fail to reject

for $z_{crit}$ use t-table with $df = \infty$

$$z_{crit} = 1.45 > 1.45$$ fail to reject
4) Your stats professor asks you to measure the happiness of 98 proud and 31 infamous brothers and obtain for proud brothers a mean happiness of 33.24 and a standard deviation of 5.4555, and for infamous brothers a mean of 34.76 and a standard deviation of 6.0071.

Make a bar graph of the means with error bars representing the standard error of the means.

Using an alpha value of 0.01, is the mean happiness of proud brothers significantly different than for the infamous brothers?

What is the effect size?

What is the observed power of this test?

$x$: proud brothers $\bar{x} = 33.24 \quad n_x = 98 \quad s_x = 5.4555$

$y$: infamous brothers $\bar{y} = 34.76 \quad n_y = 31 \quad s_y = 6.0071$

$H_0: \mu_x = \mu_y$

$H_1: \mu_x \neq \mu_y$

$\alpha = .01$, two-tailed test

$S_p = \sqrt{\frac{(n_x-1)s_x^2 + (n_y-1)s_y^2}{n_x+n_y-2}} = 5.8326$

$S_{x-y} = S_p \sqrt{\frac{1}{n_x} + \frac{1}{n_y}} = 1.1505$

$t = \frac{\bar{x} - \bar{y}}{S_{x-y}} = 1.32$

$d.f. = n_x + n_y - 2 = 98 + 31 - 2 = 127$

fail to reject

see the answer from the tutorial:
4) The happiness of proud and infamous brothers

\[ \bar{x} - \bar{y} = 33.24 - 34.76 = -1.52 \]

\[ s_p = \sqrt{\frac{(98-15.4555)^2 + (31-1)6.0071^2}{(98-1)+(31-1)}} = 5.5907 \]

\[ s_{x-y} = 5.5907 \sqrt{\frac{1}{98} + \frac{1}{31}} = 1.152 \]

\[ t = \frac{\bar{x} - \bar{y}}{s_{x-y}} = \frac{33.24 - 34.76}{1.152} = -1.32 \]

\[ t_{crit} = \pm 2.62 (df = 127) \]

We fail to reject \( H_0 \).

The happiness of proud brothers (\( M = 33.24, \ SD = 5.4555 \)) is not significantly different than the happiness of infamous brothers (\( M = 34.76, \ SD = 6.0071 \)) \( t(127) = -1.32, \ p = 0.1892 \).

The effect size is \( d = \frac{\bar{x} - \bar{y}}{s_p} = \frac{|33.24 - 34.76|}{5.5907} = 0.27 \)

This is a small effect size.

The observed power for two tailed test with an effect size of \( d = 0.27, \ n = \frac{(98+31)}{2} = 65 \) and \( \alpha = 0.01 \) is 0.1400.

\[ s_{\bar{x}} = \frac{5.4555}{\sqrt{98}} = 0.5511 \]

\[ s_{\bar{y}} = \frac{6.0071}{\sqrt{31}} = 1.0789 \]