"Statistical Spidey knows the score." by Matthew B. Wall
https://computingforpsychologists.wordpress.com/2013/04/11/comment-on-the-button-et-al-2013-neuroscience-power-failure-article-in-nrn/

Introduction to Biostatistics
Lecture 9A

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What shall we learn today?

This:

- statistical power and it's relation to
- sample size calculations (to get power), and give an
- example using resampling (bootstrap).

How to make 'null' results meaningful

Generally, it 'H_0 not rejected' is uninformative *unless* we know that the study had a good chance of detecting an effect that is interesting.

E.g: "Two methods of pain relief were compared. The difference was not statistically significant."

This would be enhanced by;

"The study was designed to have a 90% chance of detecting a clinically significant difference of 9 (on the VAS scale)".

Attempt to visualize the power of a test

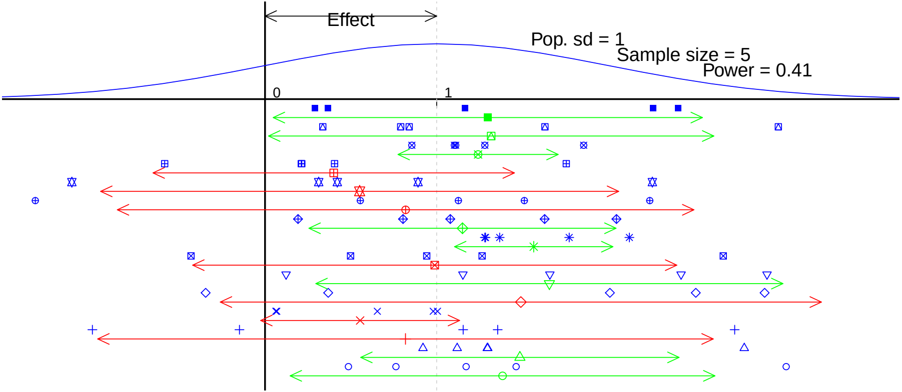
Suppose we measure the effect of a drug that on average does decrease the blood pressure by a clinically significant amount (defined as 1 unit).

We measure the blood pressure on n indivuals before and after taking the drug.

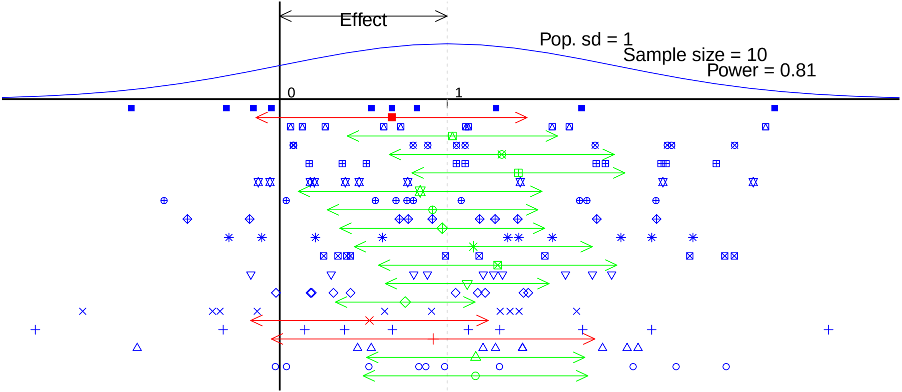
Our data consist of n 'indivual effects' (before - after) which are positive if the drug works. We assume these are Normal with a standard deviation of 1 unit.

H_0 :"average effect $= 0$" is determinded by creating a 95% confidence interval for the mean effect.

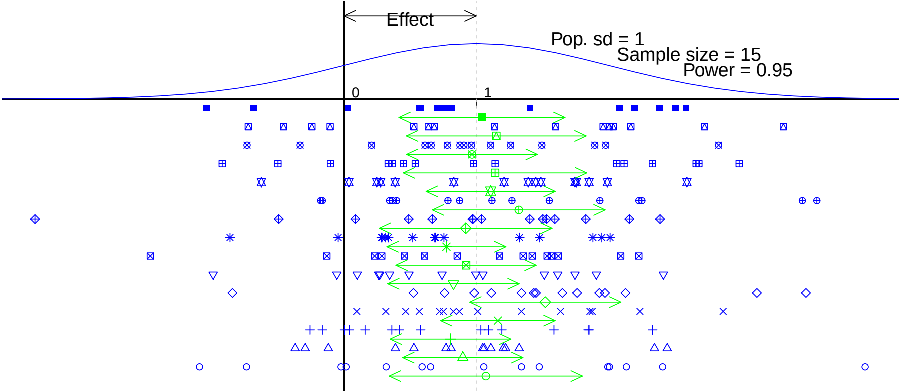
A sample size of 5



A sample size of 10



A sample size of 15



Power

The power of a test is the probability of rejecting the null hypothesis.

The power depends on

- effect size
- sample size
- the spread of the data
- (the statistical test, significance level, etc.)

If there is no effect, the power = the significance level (the probability of rejecting a true null hypothesis)

We want a test to have high power as soon as the effect is *interesting*.

Some points

- In an experimental setting, you can control the sample size.
- (You might be able to reduce measurement error.)
- We usually express the power as a function of effect- and sample size.
- We usually want high power ($\geq 80\%$) at some minimally interesting effect size.
- Sample size calculations are generally gruesome, but
  - software exists, and
  - other techniques might suffice.

Sample size calculations without a model

Recall the breastfeeding example from lecture 4.

pair	1	2	3	4	5	6	7	8	9	10	11	12	13
bottle	8	8	31	8	13	21	26	39.0	77.0	29	35	182	186
breast	7	10	28	12	19	14	15	51.0	65.0	12	11	24	17
diff	1	−2	3	−4	−6	7	11	−12.0	12.0	17	24	158	169
rank	1	2	3	4	5	6	7	8.5	8.5	10	11	12	13

part	rank	sum
negative	2, 4, 5, 8.5	19.5
positive	1, 3, 6, 7, 8.5, 10, 11, 12, 13	71.5

The null hypothesis of no difference was tested with the Wilcoxon signed rank test. (This tests for a shift in median.)
The p-value was 0.07

Think of this as being a pilot study and assume the data is representative of some target population. If the observed effect, a median shift of 9 days, is considered interesting (and thought to be true) what sample size would we need in order to show this?

Two possible approaches:

- Make a model for the data (possibly transforming to the Normal distribution if possible) and solve analytically (via software most likely)
- "Pull yourself up by your own bootstraps" - resample from the pilot study data.

In the latter case we will simulate a study (actually, many) by using the given sample:

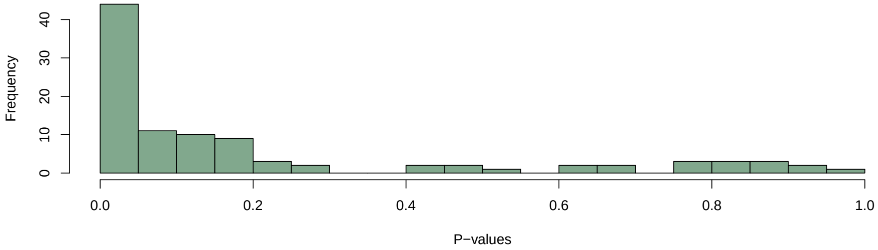
$$1, -2, 3, -4, -6, 7, 11, -12, 12, 17, 24, 158, 169$$

Resampling using the same same sample size (13).

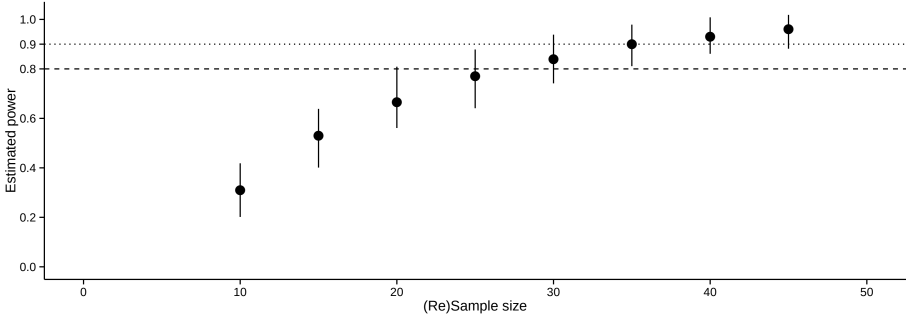
$$12, 24, 12, -6, 169, 7, 11, 12, 1, -6, 24, 3, 12, -4$$

We are interested in the power of the test, so we want to see how often the null is rejected. For that purpose we collect the p-value. In this case it is 0.012.

Now lets repeat this process 100 times. What kind of p-values do we get?



These 100 'regenerated' *p*-values, suggest that the power was 0.44.
This is an estimate! (The error will depend on both the resample *and* inital sample.)
The plot shows a bootstrap estimate for varying sample sizes:



So you should probably use at least 35 individuals.

References

- Chapters 23-25: Petrie & Sabin. *Medical Statistics at a Glance*, Wiley-Blackwell (2009).