How can I use power analysis to determine the sample size needed for a one-sample t-test in SAS?

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Power analysis is a statistical tool used to estimate the sample size needed for a particular study or experiment. In the context of a one-sample t-test in SAS, power analysis can be used to determine the minimum sample size required to detect a specific effect size with a desired level of statistical power. This involves specifying the desired level of significance, effect size, and power, and using statistical software such as SAS to calculate the appropriate sample size. By using power analysis, researchers can ensure that their study has enough statistical power to detect meaningful differences between groups, thereby increasing the reliability and validity of their findings.

Power Analysis for One-sample t-test | SAS Data Analysis Examples

Examples

Example 1. A company that manufactures light bulbs claims that a particular type of light bulb will last 850 hours on average with standard deviation of 50. A consumer protection group thinks that the manufacturer has overestimated the lifespan of their light bulbs by about 40 hours. How many light bulbs does the consumer protection group have to test in order to prove their point with reasonable confidence?

Example 2. It has been estimated that the average height of American white male adults is 70 inches. It has also been postulated that there is a positive correlation between height and intelligence. If

this is true, then the
average height of a white male graduate students on campus
should be greater than the average height of American white male adults
in general. You want to test this theory out by random sampling a small group of
white male graduate students. But you need to know
how small the group can be or how few people that you need to measure
such that you can still prove your point.

Prelude to The Power Analysis

For the power analysis below, we are going to focus on Example 1 testing the
average lifespan of a light bulb. Our first goal is to figure out the number of
light bulbs that need to be tested. That is, we will determine the sample
size for a given a significance level and power. Next, we will reverse the process
and determine the power, given the sample size and the significance

level.

We know so far that the manufacturer claims that the average lifespan of the light bulb is 850 with the standard deviation of 50, and the consumer protection group believes that the manufactory has overestimated by about 40 hours. So in terms of hypotheses, our null hypothesis is H0 = 850 and our alternative hypothesis is Ha= 810.

The significance level is the probability of a Type I error, that is the probability of rejecting H0 when it is actually true. We will set it at the .05 level. The power of the test against Ha is the probability of that the test rejects H0. We will set it at .90 level.

We are almost ready for our power analysis. But let's talk about the standard deviation a little bit. Intuitively, the number of light bulbs we need to test depends on the variability of the lifespan of these light bulbs. Take an extreme

case where all the light bulbs have exactly the same lifespan. Then we just need to check a single light bulb to prove our point. Of course, this will never happen. On the other hand, suppose that some light bulbs last for 1000 hours and some only last 500 hours. We will have to select quite a few of light bulbs to cover all the ground. Therefore, the standard deviation for the distribution of the lifespan of the light bulbs will play an important role in determining the sample size.

Power Analysis

In SAS, it is fairly straightforward to perform a power analysis for comparing means. For example, we can use proc power of SAS for our calculation as shown below. First, we specify the two means, the mean for the null hypothesis and the mean for the alternative hypothesis. Then we specify the standard deviation for the population. The default

significance level (alpha level) is at .05 so we are not going to specify it. The power is set to be .9.
Last, we tell SAS that we are performing a one-sample t-test.

```
proc power;
onesamplemeans test=t
nullmean = 850
mean = 810
stddev = 50
power = .9
ntotal = . ;
run;
```

One-sample t Test for Mean

Fixed Scenario Elements

Distribution Normal
Method Exact
Null Mean 850
Mean 810
Standard Deviation 50
Nominal Power 0.9

Number of Sides 2

Alpha 0.05

Computed N Total

Actual N

Power Total

0.909 19

The result tells us that we need a sample size at least 19 light bulbs to reject H0 under the alternative hypothesis Ha to
have a power of 0.9.

Next, suppose we have a sample of size 10, how much power do we have keeping all of the other
numbers the same? We can use the same program to calculate it.

```
proc power;
onesamplemeans test=t
nullmean = 850
mean = 810
stddev = 50
```

power = .

ntotal = 10 ;

run;

One-sample t Test for Mean

Fixed Scenario Elements

Distribution Normal
Method Exact
Null Mean 850
Mean 810
Standard Deviation 50
Total Sample Size 10
Number of Sides 2
Alpha 0.05

Computed Power

Power

0.616

You can see that the power is about .616 for a sample size of 10. What then is the power for

sample size of 15 or 20? We can use a list of sample sizes as input to proc power.

```
proc power;
onesamplemeans test=t
nullmean = 850
mean = 810
stddev = 50
power = .
ntotal = 10 to 45 by 5 ;
run;
```

One-sample t Test for Mean

Fixed Scenario Elements

Distribution Normal
Method Exact
Null Mean 850
Mean 810
Standard Deviation 50
Number of Sides 2
Alpha 0.05

Computed Power

N

Index Total Power

1 10 0.616

2 15 0.821

3 20 0.924

4 25 0.970

5 30 0.988

6 35 0.996

7 40 0.999

8 45 >.999

We can also expect that if we actually know that the standard deviation is
smaller, then the sample size could be also be smaller. We can experiment with
different values of standard deviation as shown below.

proc power;

onesamplemeans test=t

nullmean = 850

mean = 810

stddev = 30 to 100 by 10

power = .8

ntotal = . ;

run;

One-sample t Test for Mean

Fixed Scenario Elements

Distribution Normal

Method Exact

Null Mean 850

Mean 810

Nominal Power 0.8

Number of Sides 2

Alpha 0.05

Computed N Total

Std Actual N

Index Dev Power Total

1 30 0.834 7

2 40 0.803 10

3 50 0.821 15

4 60 0.807 20

5 70 0.815 27

6 80 0.808 34

7 90 0.803 42

8 100 0.808 52

Discussion

There is another technical assumption, the normality assumption. If the
variable is not normally distributed, a small sample size usually will not have the
power indicated in the results, because those results are calculated using the common method based on the normality assumption. It
might not even be a good idea to do a t-test on such a small sample to begin with
if the normality assumption is in question.

Here is another technical point. What we really need to know is the difference between the two means, not the individual values. In fact, what really matters is the difference of the means
over the standard deviation. We call this the effect size. For example, we would
get the same power if we subtracted 800 from each

mean, changing 850 to 50 and 810 to 10.

proc power;
onesamplemeans test=t
nullmean = 50
mean = 10
stddev = 50
power = .9
ntotal = . ;
run;

One-sample t Test for Mean

Fixed Scenario Elements

Distribution Normal
Method Exact
Null Mean 50
Mean 10
Standard Deviation 50
Nominal Power 0.9
Number of Sides 2
Alpha 0.05

Computed N Total

Actual N
Power Total

0.909 19

If we standardize our variable, we can calculate the means in terms of change in standard deviations.

```
proc power;
onesamplemeans test=t
nullmean = 1
mean = .2
stddev = 1
power = .9
ntotal = . ;
run;
```

One-sample t Test for Mean

Fixed Scenario Elements

Distribution Normal
Method Exact
Null Mean 1

Mean 0.2

Standard Deviation 1

Nominal Power 0.9

Number of Sides 2

Alpha 0.05

Computed N Total

Actual N

Power Total

0.909 19

It is usually not an easy task to determine the "true" effect size. We make our best guess based upon the existing literature or a pilot study. A good estimate of the effect size is the key to a successful power analysis.

See Also

D. Moore and G. McCabe, Introduction to the Practice of Statistics, Third Edition, Section 6.4.