tutorial STAT 210 Hypothesis testing

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What is the scientific method?

Check Armstrong, J., & Green, K. (2022). The Scientific Method: A Guide to Finding Useful Knowledge. Cambridge: Cambridge University Press. doi:10.1017/9781009092265

one important aspect of science is to follow the scietific method to build knowledge

How? building knowledge from previous information Develop Multiple Reasonable Hypotheses With Specified Conditions Prior to Any Analysis

First step is to understand the important problem to solve

a. Designing a study to gather more information: there is the class in design of experiments.
b. Perform data analysis:
c. explore the data

Provides constrains; illustrate what assumptions can be made; make clear what analysis are viable.

what is a hypothesis?

Is an explanation based on evidence

why we need to be clear about the H0 and H1 ?

reject H0 is the same to accept H1? No, the issue is that every study is limited and only provide evidence but a small study cannnot provide a full proof.

Error Type 1

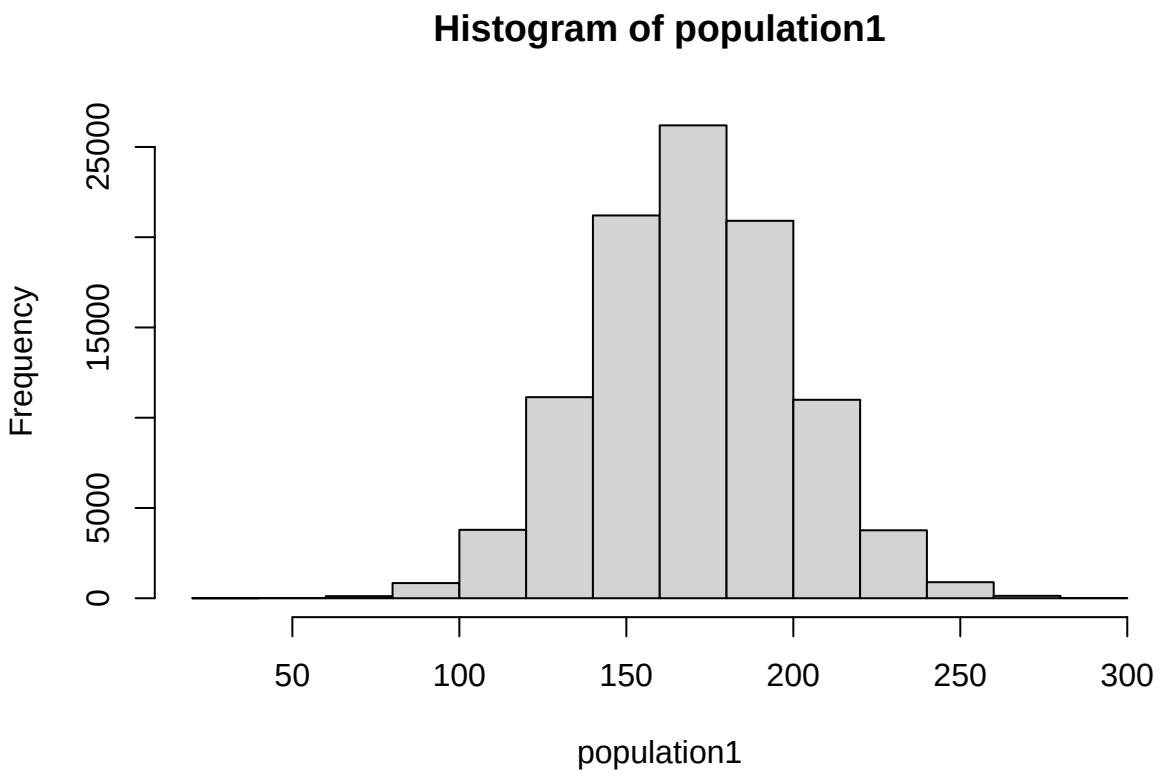
Reject H0 (the null hypothesis) when is TRUE

Example: a population 100 k trees with mean height of 1.70 m

H0: the mean height is 1.70 m (which is true!!!)

H1: the mean height is NOT 1.70 m

```
## population simulation

population1<- rnorm(100000, mean=170, sd=30 )

hist(population1)
```



Lets makes a study of this population

```
Sample1<- sample(population1, 50, replace = F)

mu<-mean(Sample1)

mysd<-sd(Sample1)

myt<- t.test(Sample1,mu=170)

myt$p.value
```

```
## [1] 0.5696577
```

```
for(i in 1:1000){
Sample1<- sample(population1, 50, replace = F)

myt<- t.test(Sample1,mu=170)

if( myt$p.value<.05 ){break}

}
i
```

```
## [1] 6
```

How many times will be rejected the null hypothesis i.e. how many times we will commit the error type 1???

```
mypvals<-c()
 for(i in 1:1000){
    Sample1<- sample(population1, 50, replace = F)

    myt<- t.test(Sample1,mu=170)

    mypvals[i]<-  myt$p.value

  }

sum( mypvals<.05 )
```

```
## [1] 48
```

Which is a 5% of error type I

Therefore, the threshold of the pvalue or the significance is a limit on how much error type 1 we are allowed to commit the implication should be related to each experiment.

Error type II

Fail to reject the null hypothesis when is not true. Lets use the same example but with a different hypothesis

H0: the mean height is 1.60 m (Now this is false)

H1: the mean height is NOT 1.60 m

I have not changed the population, lets take a sample

Remember, "doing things right" and now "being correct" is to Reject H0 because H0 is now false.

```
Sample2<- sample(population1, 50, replace = F)

mean(Sample2)
```

```
## [1] 169.8115
```

```
sd(Sample2)
```

```
## [1] 33.81801
```

```
for(i in 1:10000){
  Sample2<- sample(population1, 50, replace = F)

  myt<- t.test(Sample2,mu=160)

  if( myt$p.value>=.05 ){break}

}
i
```

```
## [1] 5
```

How much will be now the percentage of our errors type II???

```
mypvals2<-c()
for(i in 1:1000){
  Sample2<- sample(population1, 50, replace = F)

  myt<- t.test(Sample2,mu=160)

  mypvals2[i]<-  myt$p.value

}

sum( mypvals2>=.05 )
```

```
## [1] 367
```

This is a huge percentage.This is why important to consider that this tests can fail, depending on different factors, some times is just chance, then the conclusions should be carefully made.

power of a test is $1 - Probability\ of\ error\ type\ II$

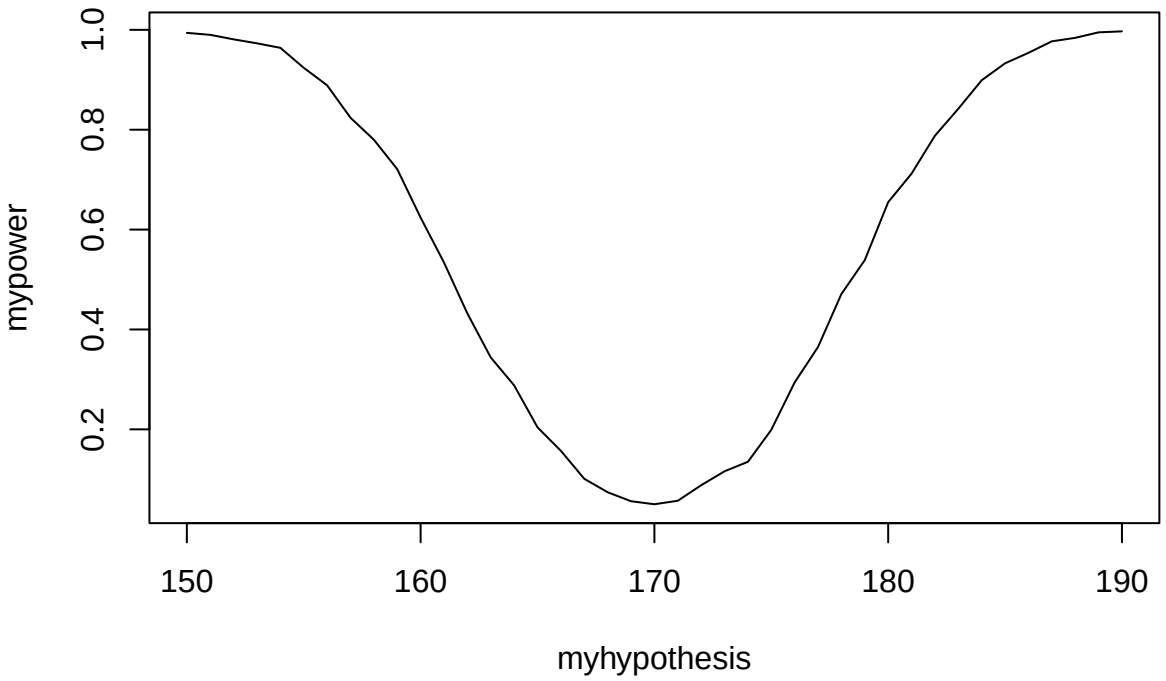
In the last case is

```
1-sum( mypvals2>=.05 )/1000
```

```
## [1] 0.633
```

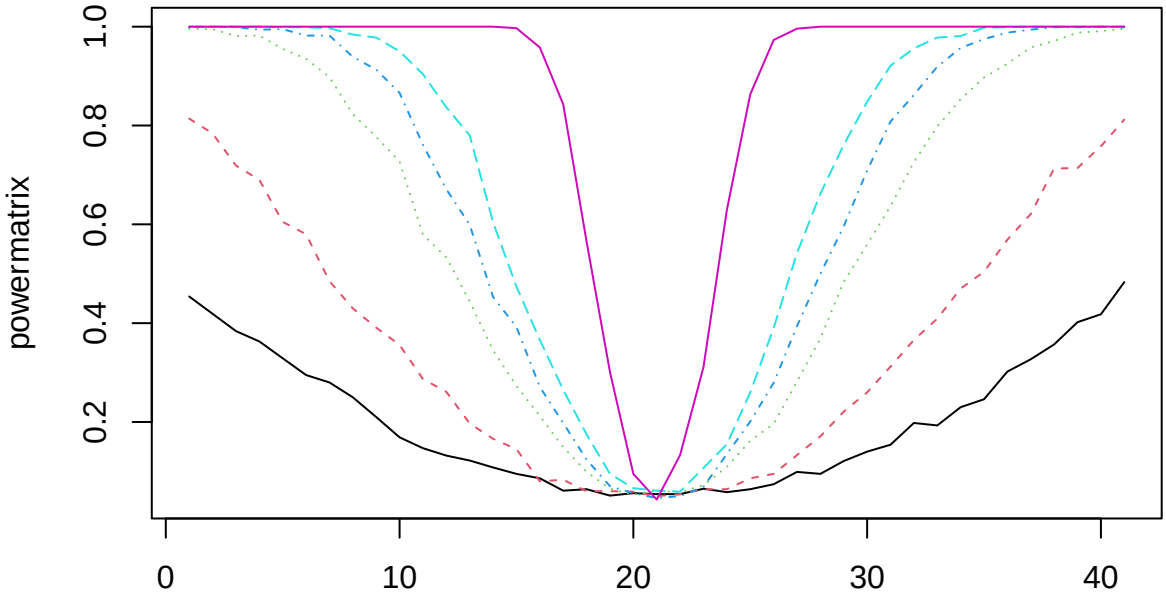
The power can depend on the sample size and the hypothesis. Lets check a range of hypothesis

```
myhypothesis<-150:190
mypower<-c()
for(k in 1:length(myhypothesis) ){

mypvals2<-c()
for(i in 1:1000){
  Sample2<- sample(population1, 50, replace = F)

  myt<- t.test(Sample2,mu=    myhypothesis[k]   )

  mypvals2[i]<-  myt$p.value

}

mypower[k]<- 1-sum( mypvals2>=.05 )/1000


}

plot(myhypothesis, mypower, type="l")
```



now lets see the power when the sample size increase

```
myhypothesis<-150:190
samplesizes<-c( 10,20,50,70,100,500)
powermatrix<-matrix (0, length(myhypothesis), length(samplesizes)  )

for(j in 1:length(samplesizes)){
mypower<-c()
for(k in 1:length(myhypothesis) ){

  mypvals2<-c()
  for(i in 1:1000){
    Sample2<- sample(population1, samplesizes[j] , replace = F)

    myt<- t.test(Sample2,mu=    myhypothesis[k]   )

    mypvals2[i]<-  myt$p.value

  }

  mypower[k]<- 1-sum( mypvals2>=.05 )/1000


}

powermatrix[,j]<-mypower

}

samplemat<- matrix( rep(samplesizes, length(myhypothesis)), nrow = length(myhypothesis), byrow = T  )

matplot(  powermatrix, type="l")
```



Increasing the sample size makes the test (more powerful) to detect when Ho is false. Along with setting a small p-value we also make the test able to detect H0 that are true with a small probability of error.

p-value

P-value is the maximum probability of getting the observed outcome by chance.

Sil A, Betkerur J, Das NK. P-Value Demystified. Indian Dermatol Online J. 2019 Nov 1;10(6):745-750. doi: 10.4103/idoj.IDOJ_368_19. PMID: 32195200; PMCID: PMC6859766.

Improving homework reports

1. divide the questions by verbs and be explicit for instance: HW4 Q1 part d)

We want to determine whether the treatment had an impact on the memory score of the patients. State clearly the statistical hypothesis that you want to test.

The statistical hypothesis that I want to test is

$H0$: ...

$H1$: ...

What test or tests would you consider adequate in this situation

I consider adequate in this situation to use...

and why?

The test is adequate because...

What are the assumptions?

The assumptions are...

Are they satisfied in this case?

Let's check one by the one the assumptions in all ways seen in class by ...

Carry out all appropriate tests for this problem

first test...

The results indicate... because

Second test...

The suresults indicate... because

test # N ...

The suresults indicate... because

and comment on your results

overall,...

2. Always shortly comment
3. Be concise (helps with time)

Alternatively use the examples from the slides as guide

slides week 6: V21 - Comparing Proportions

Example 1

We want to test

$$H0 : p = \ vs \ p <$$

and choose a level alpha =

We have

$$n =,$$
$$n_A =,$$
$$\pi =,$$
$$n \times p = \times => \quad and$$
$$n \times (1 - p) = \times =>$$

we compute the p value ...

we observed that... and conclude