Hypothesis Testing Part I

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Objective

- Purpose
- How to construct the Hypothesis
- One and Two Tailed Tests
- Procedure of Hypothesis testing
- P value
- t Test
- Assumption of t Test
- Use of SPSS

Introduction

- Covid 19
- Human beings are progressive in nature.
- Decisions of life - are mostly governed by our Past experiences.
- Decisions- Subjective or Objective
- Subjective- it depends on subject (person' perception of viewing issues)- but this cant be universalised
- Objective- Based on Scientific Law- widely accepted , it works well in similar situations.

Introduction

- We try to identify optimum decision in a given situation to solve a problem.
- Statistical Inference : We use a small sample to learn about an entire population. Theory of S. I. (Statistical Inference) Provide optimum solution to a particular problem.
- S.I. Includes testing of hypothesis.

Introduction

Suppose

You may like to know

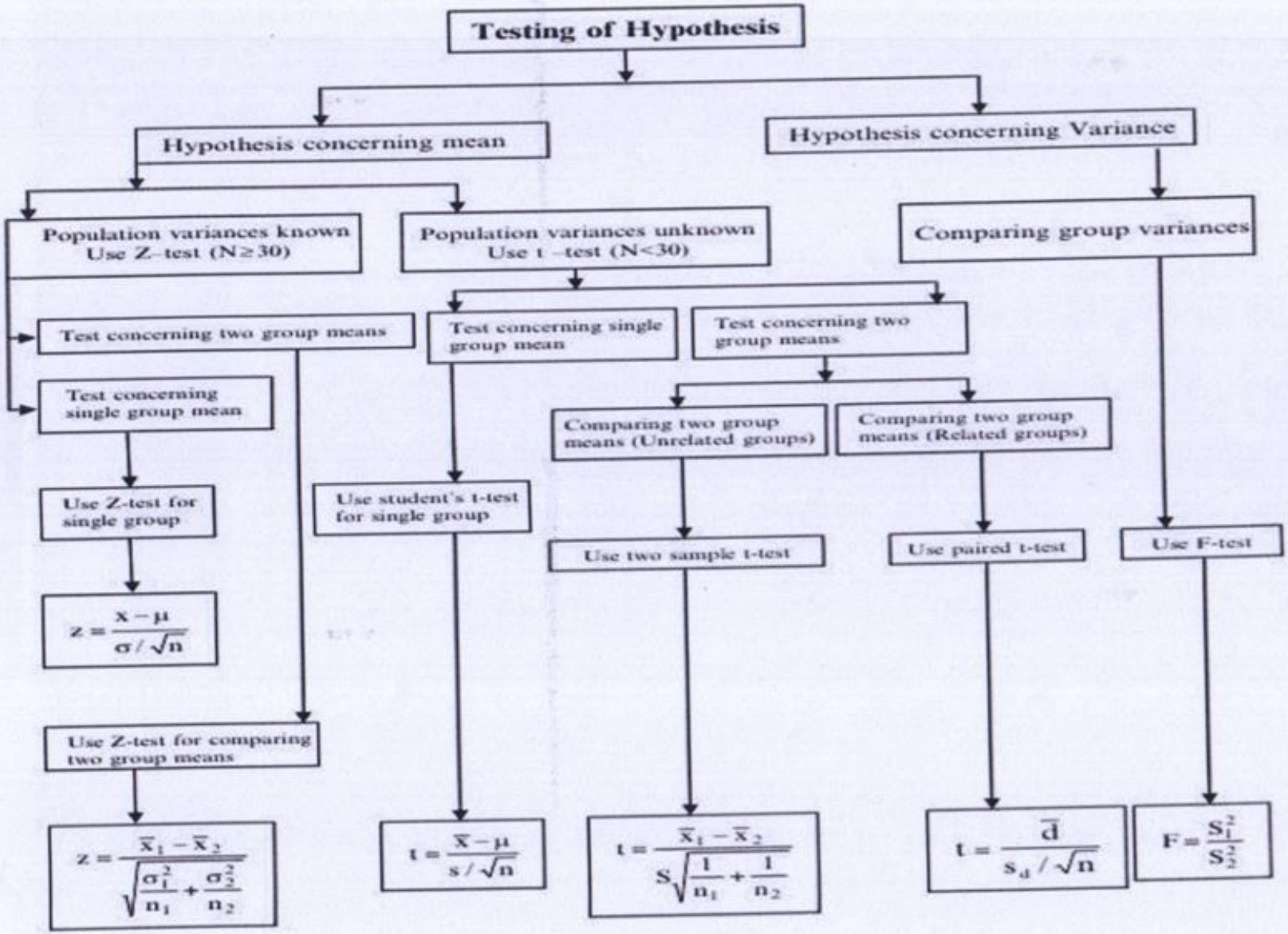
a. Whether the population mean is equal to a given value. (A representative Sample Survey)
b. Whether memory retention power is more in girls or boys in a particular age category. (Compare sample means of two population).
c. Impact of advertisement campaign on sale of a product

Introduction

- Two Statistical Tests- "t" and "z"
- Small sample (if n< or = 30)- t test
- Large sample (if n>30)- z test
- t test is used if Distribution of population is normal and population variance is not known.
- z test is used if Distribution of population is normal and population variance is known.

- Testing Hypothesis- Population Mean and Variance (normally these two are used to describe the nature of data.)
- We will concentrate on Mean aspect of data.

Plan of Choosing A Statistical Test for Hypothesis Testing



Hypothesis Construction

- Measurement of Population Characteristics
- Parameter- Mean and Variance
- If hypo. Test. is based on these parameters- Parametric Test
- If characteristics are qualitatively measured than- Non Parametric Hypothesis – Non Parametric Test

Statistical hypothesis

If

- ❑ The target population is clearly defined.
- ❑ Sample may be drawn from the defined population.
- ❑ The selected sample may be used to test the hypothesis.

Types

- ➢ Null Hypothesis
- ➢ Alternative Hypothesis

Null Hypothesis

- H0 : it is formulated to test an alternative hypothesis.
- It is assumed to be true.
- So that distribution of the test statistics can be well defined.
- Unbiased approach
- Normally, the purpose of researcher to try to reject the null hypothesis.

Alternative Hypothesis

- H1: Known as research hypothesis.
- It assumes that there is difference between population parameter and the sample value.

In general, the research hypothesis (H1) specifies that the population parameter is one of the following:

1. Not equal to some specified value: $\mu \neq$ some specified value
2. Greater than some specified value: $\mu >$ some specified value
3. Less than some specified value: $\mu <$ some specified value

Test Statistics

- Rejection or acceptance of hypothesis depends upon the value of test statistics.
- A test statistic is a random variable (X) that is calculated from information collected from sample and used in a hypothesis test.
- The test statistic is used to calculate the p-value.

Hypothesis test	Test statistic
Z-test	Z-statistic
t-tests	t-statistic
ANOVA	F-statistic
Chi-square tests	Chi-square statistic

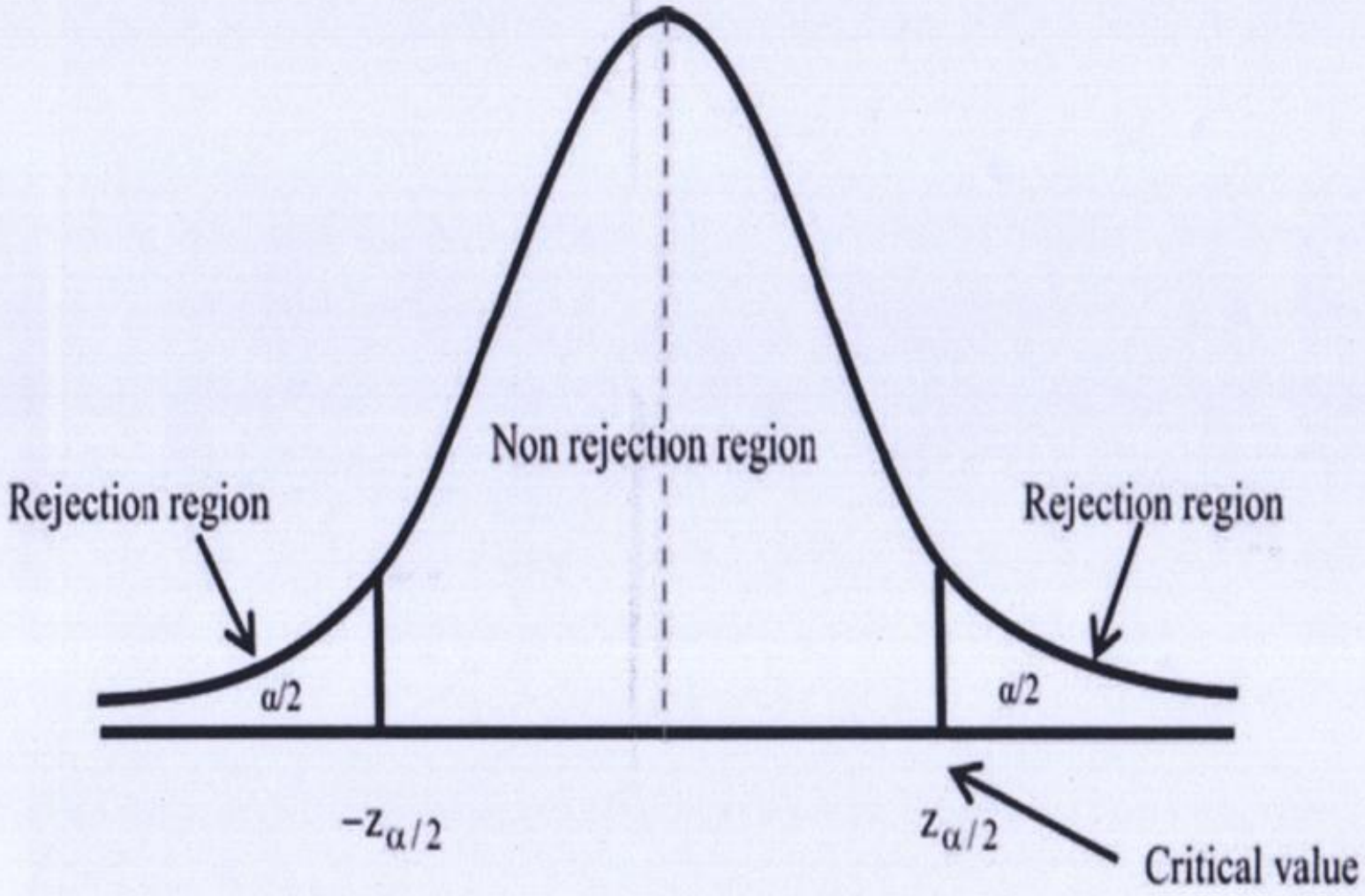
Central Limit Theorem

If sample is drawn from normal sample then sampling distribution of mean will also be. normal

- As per Central Limit theorem If the population from which sample is drawn is not normal, the sample mean will still follow the normal distribution with mean μ and variance σ^2/n provided the sample size > 30.
- For different sample size, the t curve is different, and it approaches to normal curve for sample size n>30.

Rejection Region

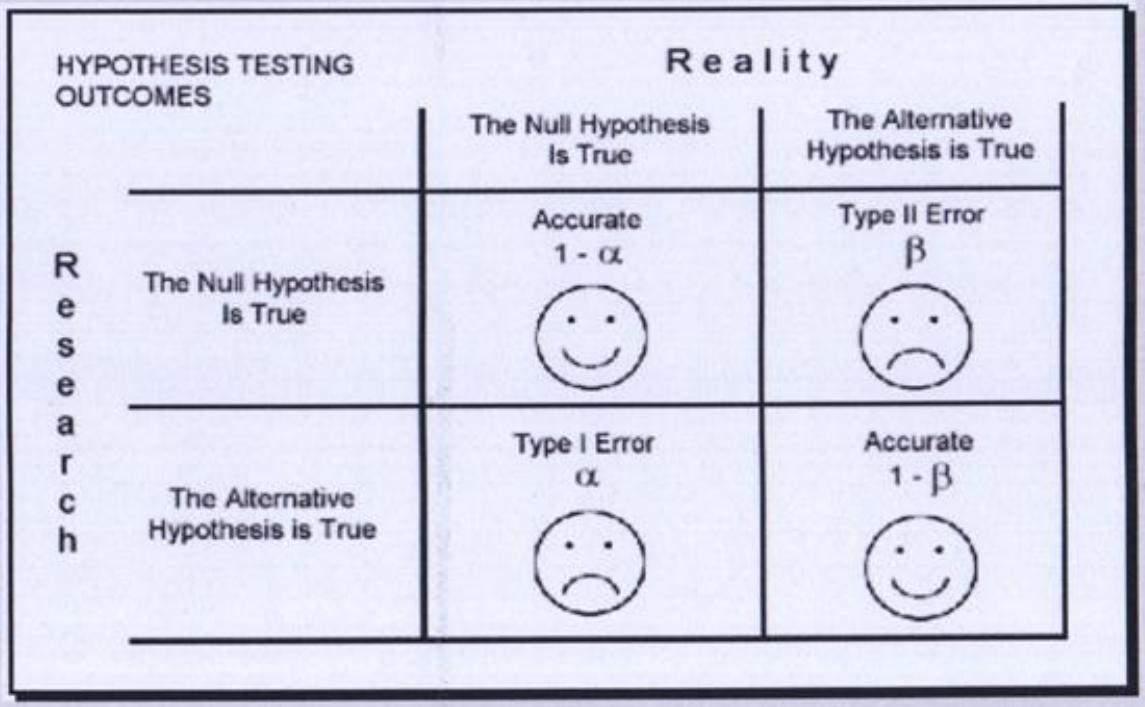
- Rejecting region: it is a part of sample space in which if the value of test statics falls then the null hypothesis is rejected. It is determined by the level of significance (alpha).
- Critical value: the value of statistics that divides sample space into two regions: Acceptance and Rejection Region.
- If test statistics falls in rejection / critical region: h0 is rejected and H1 is accepted.


Non rejection region
Rejection region
Rejection region
α/2
α/2
$-z_{\alpha/2}$
$z_{\alpha/2}$
Critical value

Steps in Hypothesis Testing

- Formulate Null and Alternative hypothesis for each parameter that has to investigated. (one tailed- two tailed)
- Choose the level of significance (range 0-1). This is also known as Type I Error. Normally we choose 0.01, 0.05 or 0.10 as level of significance.
- Identify test statics : compute its value on basis of sample data.
- Obtain tabulated value of statistics from the designated table.
- If calculated statistics> tabulated value of statistics : Reject Null Hypothesis.
- Or $p < .05$ then – reject the null hypothesis.

Type I and Type II Error



Type I and Type II Error

Type I error The probability associated with rejecting a null hypothesis when it is true.

Type II error The probability associated with failing to reject a null hypothesis when it is false

- Type II error is denoted by β (beta).
- It is used to determine power of the test.
- The term (1-β) is said to be power of test.
- The power of the test is probability of rejecting the null hypothesis when it is wrong.

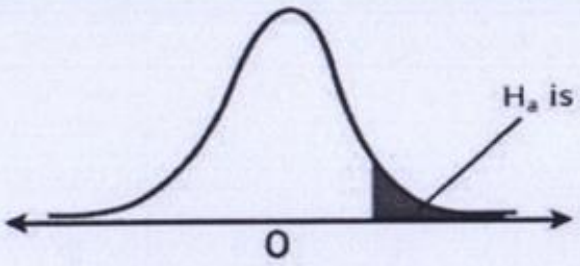
Type I and Type II Error

- α = It is not type I error, but it is the probability of type I.
- β = It is not type II error, but it is the probability of type II error.
- Since it can take any value in between o and 1.
- So one should write the statement like "null hypothesis may be rejected at .05 level of significance instead of "null hypothesis may be rejected at 5 percent level of significance.
- For fixed sample size, the reduction of both types of error is not possible. So, there are two ways to reduce these two errors.-

1. Increase the sample size. (Chance of loosing control is higher and error is possible).
2. Identify the error which is more severe. First fix it up at a desired level- then try to minimise the other.

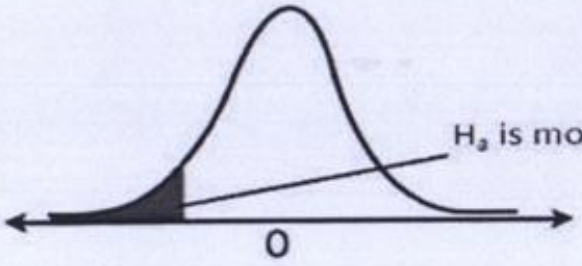
Example: Advertisement campaign, Court of law (Ho – innocent) .
Type I error is more severe than type II error.

One Tailed and Two Tailed Tests



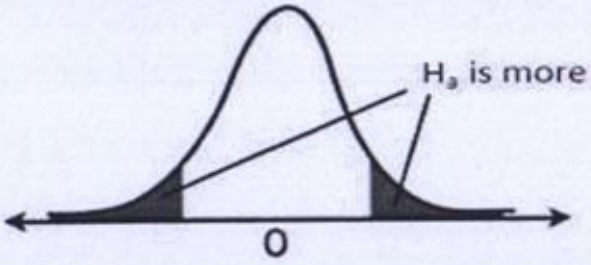
Right-tail test

$H_a: \mu > \text{value}$



Left-tail test

$H_a: \mu < \text{value}$



Two-tail test

$H_a: \mu \neq \text{value}$

Criteria For Using One-Tailed and Two-Tailed Tests

- One tail test is used when researcher is quite sure about the direction of the difference in advance(Ex. Exercise will improve fitness level).
- Significance relationship between

1. People's age and medical expenses: Ho- Expenses increases or expenses do not increase. (but never decrease with increase in age)- One tailed test.
2. People's weight and their income: it may increase or it may decrease- Two tailed test.

The advantage of using one-tailed test is that you can use a smaller sample to test it.

But, it is also easier to reject Null hypothesis in one tailed test.

Strategy in One Tailed and Two-Tailed Tests

Example:

- Average cure time of cold and cough by a newly introduced medicine X is 4 days-

Ho: $\mu = 4$ days

H1: $\mu \neq 4$ days

Sample = 64 Patients

Average recovery time= 3.5 days with s=1 day

P=0.0002

Ho is rejected.

Recovery time is not equal to 4.

Example

Ho: $\mu \geq 14$ days

H1: $\mu < 4$ days

Sample = 64 Patients

Average recovery time= 3.5 days with s=1 day

P=0.0001

Ho is rejected.

Recovery time is less than 4.

Some other important Concepts

- P Value: It is the probability of wrongly rejecting the null hypothesis.
- Degree of Freedom – any parameter can be estimated with certain amount of information or data set.
- The number of independent piece of data or scores that are used to estimate a parameter is known as Degree of Freedom.

Some other important Concepts

- Suppose sample variance is computed from a random sample of **n** independent data/scores.
- Degree of freedom of sample variance here

sample variance is calculated from sample of n score.

One degree of freedom is lost due to the condition that sum of (X- Xmean)= o

So degree of freedom of sample variance are n-1. degree of freedom is equal to the number of independent scores (n) minus the number of parameters estimated as intermediate steps (one as μ is estimated by X mean) and therefore equal to n-1.

Some other important Concepts

In case of two sample:

Pooled standard deviation s is computed by using $n1 + n2$ observations.

In computation of S two parameters $\mu 1 + \mu 2$ observations.

Degree of freedom= $(n1 + n2)--2$

Thanks

Sampling: Sample Size Determination

Part 1

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Sample statistics are always wrong (at least to some extent).

We use sample to describe not only the specific group of subject that were measured, but also the goal of sampling is to infer properties about a larger population. This practice is known as inferential statistics (it is used to draw conclusion about the population using a random sample).

For example

Like in the case of opinion poll, we not only learn opinions of those who responded to the survey but about an entire population.

Inferential Statistics

We use a small sample to learn about an entire population. To obtain good and true results we must follow some procedures that can help our sample to represent the population faithfully.

Random Error

It is also important to accept that even you follow the proper methodology for performing a valid study based on sample; your estimates will almost be at least a little wrong. That error is known as **Random error**. Your data are not 100% representative of the population, because they are not the entire population.

"How large is the difference between the estimates and real population value" (this value is also known as margin of errors) will depend on following two factors:

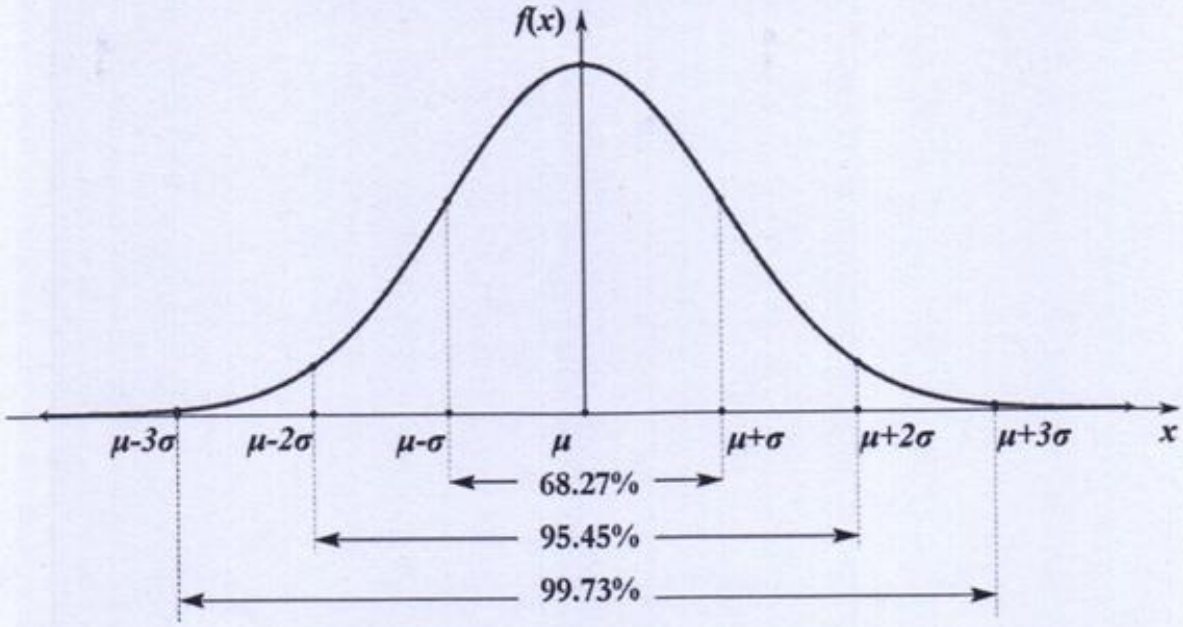
1. Sample Size
2. Variability in Data

Normally, We use sample to measure point estimates (mean, STDEV., Etc.).

Confidence intervals

Confidence intervals provide the margin of error around a point estimate. Such as M.E. around a point μ in figure 1.

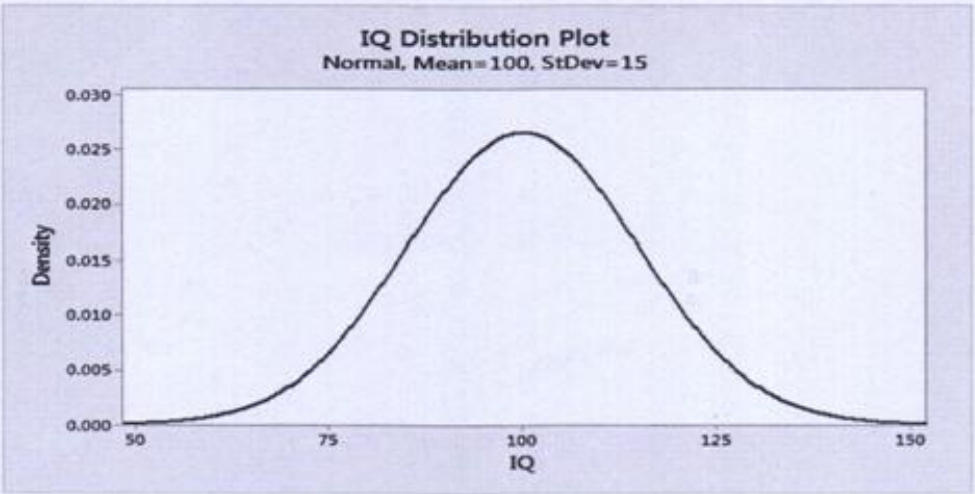
Figure 1: The sampling distribution of the mean



Please read in detail @ http://onlinestatbook.com/2/estimation/mean.html

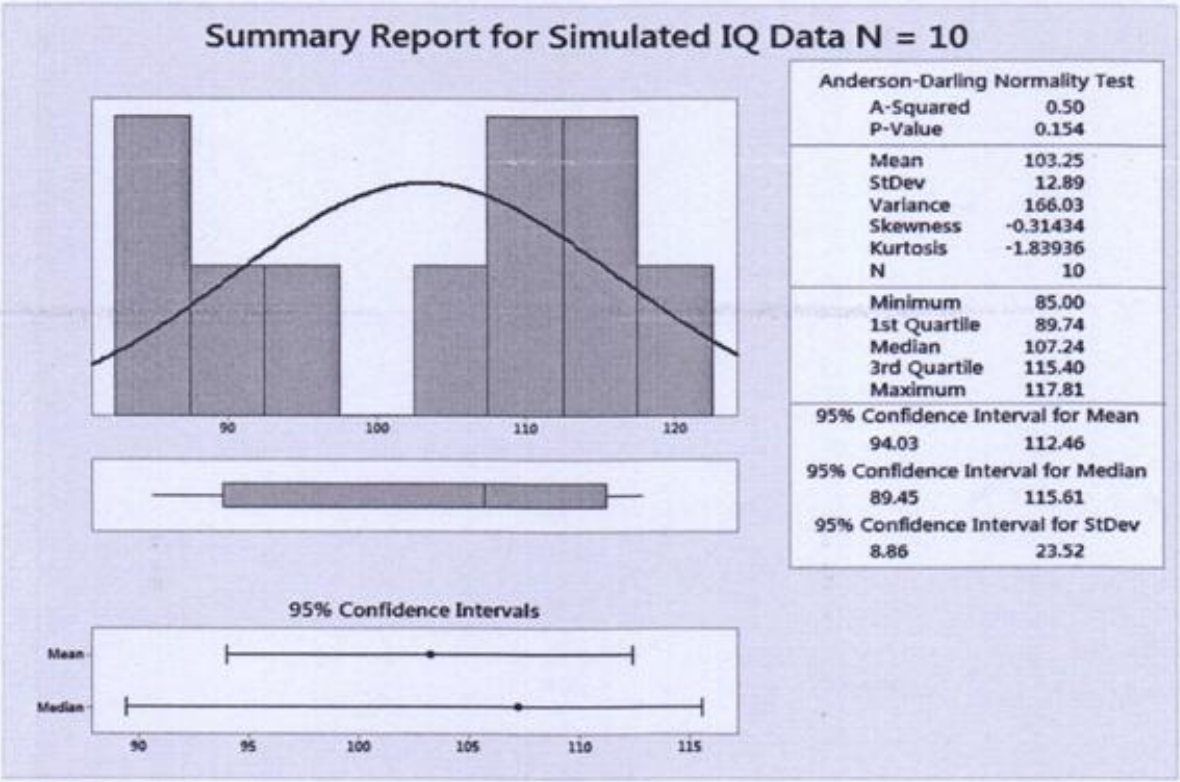
Example: there is a population that follows a normal distribution with a mean of 100 (IQ Scores) and standard deviation (STDEV) (in simple language, STDEV shows a quantity expressing by how much the members of a group differ from the mean value for the group). Data of IQ of 100 persons (total population) is also given in appendix 1. Figure 2 shows distribution of IQ. Please use Excel or STATA or SPSS to draw this graph using data given in appendix 1.

Figure 2: Distribution of students as per IQ



Suppose from given population (100) we take sample of 10, you can get following summary statistics (see figure 3):

Figure 3: Summary statistics



I request you all to select any 10 sample (select randomly) and use Excel or STATA or SPSS to analyse the summary statistics of sample population. Summary statistics of Sample can vary.

You can see differences in estimates of mean and standard deviation based on sample and population parameters.

As per sample

Mean= 103.28

STDEV= 12.89

As per population

Mena = 100

STDEV = 15

Thus, we have point estimates (mean and STDEV) and but these are not exactly same as population's real parameters.

Confidence Intervals:

Appendix 1

IQ	IQ	IQ	IQ
88.09005	107.8354	97.2742	107.1409
132.4926	83.24468	78.59256	111.3537
86.76929	89.41655	93.33648	97.21375
85.23204	116.9746	88.29573	80.29807
94.07853	125.3621	114.7941	94.34773
81.15776	93.8759	125.0234	112.3879
107.0235	126.3689	91.09926	79.98413
76.39622	87.98207	126.1878	94.23222
100.098	90.59745	79.40909	79.23603
120.2713	88.66242	116.3012	118.635
115.3938	67.93104	103.8876	113.8502
135.9646	108.2144	98.98642	106.6119
110.6402	87.05801	97.20425	77.48997
97.64312	102.5051	91.95479	104.6879
79.40919	110.905	114.8011	83.25476
103.5323	90.35819	112.9371	97.16851
82.27726	80.94495	109.7923	74.27643
112.6456	66.79982	82.93643	102.9381
110.7205	86.01018	120.9596	123.4847
115.7089	80.22605	108.4923	92.61851
81.45881	104.2439	90.30181	76.33578
105.637	86.07023	116.3847	100.4805
99.1358	90.0715	105.2939	133.0962
89.66628	103.4457	104.0452	117.6523
99.12907	96.92894	108.9816	116.6281

Sampling: Sample Size Determination

Part 2

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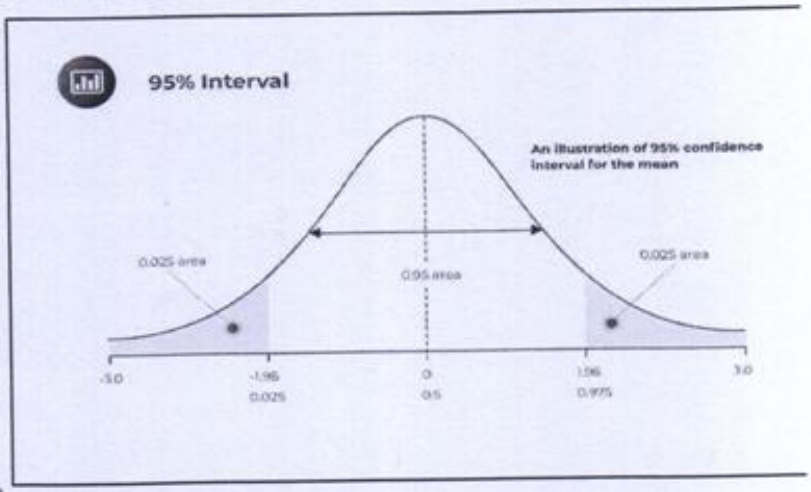

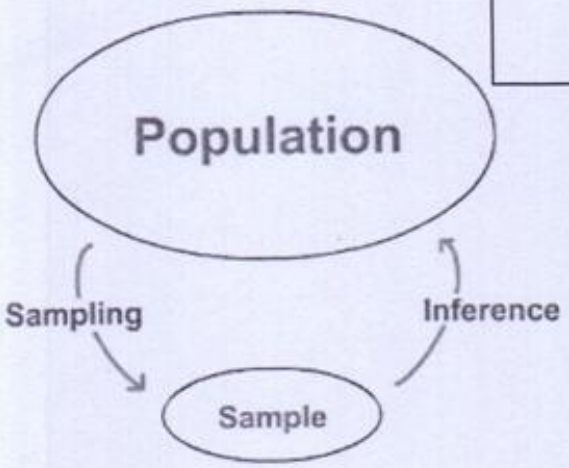

Types of population:

1. Finite population- if size of population is known.
2. Infinite population

Types of variable:

a. Continuous variable: Population Mean (Average expenditure on Health)

b. Dichotomous variable: Population Proportion (Proportion of people using polythene bags)

There are two types of estimates for each population parameter.

a. Point Estimate- Ex: Mean.

b. Confidence Intervals

Through sample survey we want to say something about θ (Population) or rather estimated θ (sample). So, it is required that estimated θ should be close to actual θ. In sample survey we estimate, predict and take decision about a population. However, such estimates are not always going to be correct. For this reason we try to measure the reliability. The measures are as following:

Confidence Interval (C.I.)
Level of significance

Confidence Interval (C.I.)

The C.I. is the proportion of times that an estimating procedure will be correct.

$$\text{Confidence Interval} = \text{sample statistic} \pm \text{Margin of error}$$

Estimate of a C.I. depends on:

1. Sample mean
2. Desired level of confidence
3. Margin of error

Sample Mean
The sample mean is a single point.

Desired Level of Significance
The level of significance measures that how frequently the conclusion will be wrong. If we use a sampling method to select different samples and if we compute interval estimates for each sample. In some cases interval estimates may include the true population parameter and some may not. Here, 90% confidence level means that we

expect that 90% of the interval estimates will include the population parameter (Mean); a 95% confidence level means that 95% of the intervals will include the parameter (mean); and so on.
If we consider C.I. at the level of 95% it means there is a 95% probability that the confidence interval will contain the true population mean.

It can be written as follows:

P([sample mean] - margin of error < μ < [sample mean] + margin of error) = 0.95.
Thus, we need to know the distribution of estimated θ (Mean). Estimated θ may follow different kinds of distributions. The normal distribution is easy to use as an example so we will concentrate on normal distribution (z) only.

Margin of Error

Margin of error = Critical value x Standard error of the statistic

Standard error (sample) of the statistic SE(x) :

$$SE_x = s / \sqrt{n}$$

Where s = sample standard deviation

n = sample size

Critical value -

If sampling distribution is normal. The critical value can be expressed as t score or as z-score.

Compute alpha (α): α = 1 - (confidence level / 100)

If confidence level is 95 then

α = 1 - (95 / 100) =.05

Then find the critical probability (p*): p* = 1 - α/2

In present case p* = 1 - α/2 = 1 - 0.05/2 = 0.975

To express the critical value as a z-score, find the z-score having a cumulative probability equal to the critical probability (p*). In case of z we assume that distribution is normal so mean will be 0 and standard deviation will be 1. So in case of 0.975 the value of z score will be 1.96.

(If the sample size is small, use the t statistic. Other wise use z statistic. But as the sample size increases t distribution gets closure to z distribution.)

> Practice Set 1. If we toss a coin two times, tell me: What is the probability that the coin tosses would result in one or fewer heads?
>
> Ans:

To express the critical value as a t statistic, follow these steps.

- Find the degrees of freedom (DF). In case of estimating mean (such as average income of rural households) or proportion from a single sample (such as proportion of workers employed in non agriculture sector), Degree of freedom is **equal to the sample size minus one.**
- The critical t statistic (t*) is the t statistic having degrees of freedom equal to DF and a cumulative probability equal to the critical probability (p*).
- If sample size is 900 than value of t score will be 1.963. that is equal to z score.

If we assume sampling distribution[1] is normal than,

Margin of error = Critical value x Standard error of the statistic

= 1.96* Standard error of the statistic

[1] Suppose that we draw all possible samples of size *n* from a given population. If we compute a statistic (e.g., a mean, proportion, standard deviation) for each sample, then the probability distribution of this statistic is called a **sampling distribution.**

C.I. will be

Confidence interval = sample statistic ± Margin of error

So,

Confidence interval= Sample Statistic ±1.96Standard error of the statistic (either z or t)

For more examples click on https://www.mathsisfun.com/data/confidence-interval.html

Home work:

Suppose: To estimate the average weight of adult males in Bihar you draw a random sample of 1,000 men from a population of 1,000,000 men and you measure their weight. If the average weight of the sample is 75 Kg and the standard deviation of the sample mean is 15 kg. Then calculate the 95% confidence interval?

Estimating Sample Size

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Introduction

- Use of Power Analysis
- Power of Hypothesis testing - The probability that the hypothesis test will detect an effect .
- Before hypothesis testing you plan for following:

  how will you collect data.

  how will you measure data (which you require for your study) among many other details.

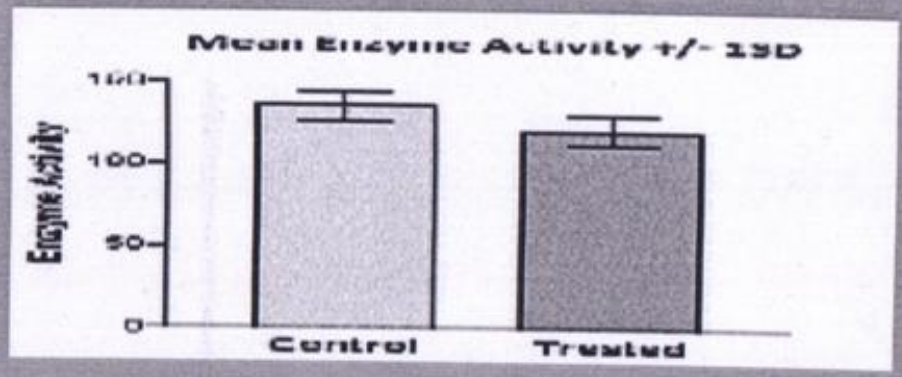
  Size of Sample

Sample Size

Here it is important to discuss what affects the statistical significance:

*** Effect : Real effect & Random Sample Error.**

Effect can be real also can not be real (due to sample error).



- To conclude that effect is real (effect of an intervention or any scheme) not random required information that may not be available to you.
- Ex: if you want to see impact of PDs on poverty, you assume a hypothesis that PDS (an intervention/scheme) reduces poverty in Bihar.
- So, here hypothesis test is important.

Continue

To estimate effect of an intervention or a variable on other variable we collect information from some sample respondents. Then we test that whether an intervention is effective or not:

Ex: Suppose we want to see impact of Laptop on Learning capacity of students: Broadly, for this we estimate the learning capacity of students those are using laptop (sample of such students) and those who are not using laptop (sample of such students). Or we can estimate difference in students' learning outcome before using laptop and after using laptop. Thus, we use sample estimate of the effect size.

Continue

- If the effect-size (effect of an variable on other variable/effect of an intervention) is large then there is less likely to be random error.
- Sample Size: But if sample size is Large then it allows hypothesis test to detect smaller effects of an intervention/ variables.
- If there is sufficient variability across sample, then random error can generate large difference.
- Hypothesis test uses information on all three points (sample size, effect, variability) given above to calculate p value. We use p value to estimate statistical significance.
- For good sample you must be aware of i) Size of the effect (effect of an intervention), ii) The sample size, and iii) The variability (variance/heterogeneity) present in the sample data, as all are correlated.

Power of A Test

- Here important is that with the help of sample we must correctly infer that an intervention has effect. Such as : Effect of smart classes on student's learning capacity.
- It means a hypothesis test should correctly rejects a false null hypothesis (we assume that there is no effect of a intervention/no effect of a variable on other variable). Consequently, power of a Hypothesis test is inversely related to the Type II error.

$$\text{Power} = 1 - \beta.$$

If power of a study is 90 percent then it means that the study has 90 percent chance of detecting an effect that exist in reality.

Continue

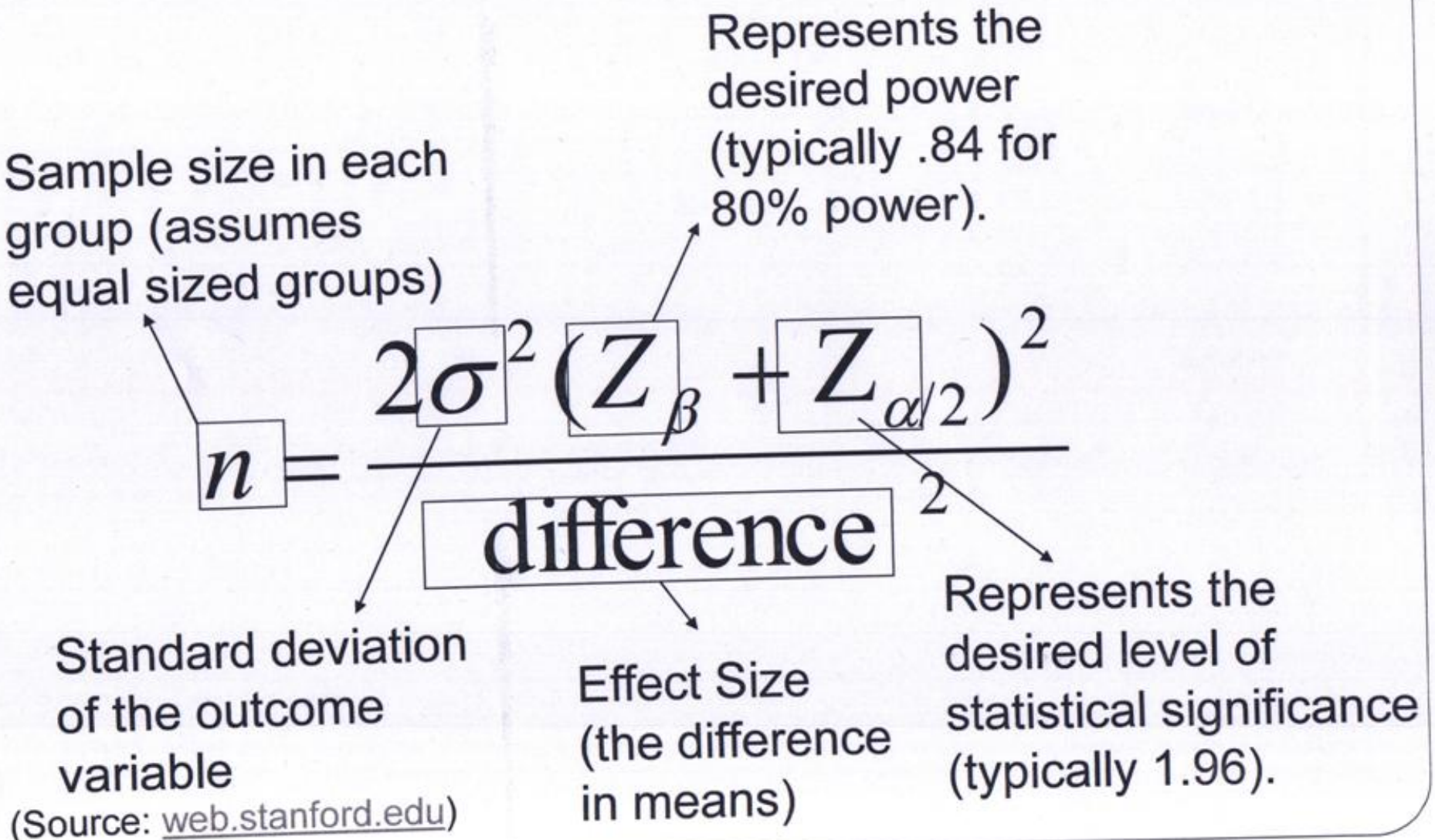
- As you increase the sample size you can detect a smaller effect.
- Thus, if there is very small effect and, you want to estimate that small effect, then you have to select a large sample size.

- Here, three things are important for sample size collection:
    1. Differences (Effect)
    2. Power Value (Type II Error)
    3. Standard Deviation (Variation)

Sample size

- Level of significance
- Select an appropriate Differences
- Power Value- Normally we take 0.8/0.9.
- Standard deviation- can be based on pilot survey or earlier estimate (as per previous study or based on previous survey data).

Simple formula for difference in means



(Source: web.stanford.edu)

Simple formula for difference in proportions

Represents the desired power (typically .84 for 80% power).

Sample size in each group (assumes equal sized groups)

$$n = \frac{2(\bar{p})(1-\bar{p})(Z_{\beta} + Z_{\alpha/2})^2}{(p_1 - p_2)^2}$$

A measure of variability (similar to standard deviation)

Effect Size (the difference in proportions)

Represents the desired level of statistical significance (typically 1.96).

(Source: web.stanford.edu)

References

- https://sphweb.bumc.bu.edu/otlt/MPH-Modules/BS/BS704_Power/BS704_Power5.html
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2876926/
- PDF of a chapter is also attached.
- See all 16 videos: https://www.youtube.com/watch?v=QBONLUp7i28&list=PLN5IskQdgXWmExGRjdy0s0VCdYnzGMZrT

Power Point Presentation

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Principles of good thesis/article

- Make sure that your work is easy to follow.
- Keep the writing clear.
- Use good sentences structure.
- Do not use technical languages.
- Omit unnecessary details.
- Stress practical action.
- Communicate visually as well as verbally.
- Use visual devices.
- Objectivity – Use passive voice
- Spelling- Read your work after spell check.

Introduction

- **Get prepared:**
- Ask yourself three things:

What is the objective of my talk? (to highlight new data, give an overview of my research, etc.)

Which main points do I want to present?

Which key message do I want people to remember after my talk is over?

Introduction

- Make a list of the answers to the questions as the starting point for your presentation.
- Then sketch out your presentation (Slides) in draft form, using keywords and bullet points rather than complete sentences.
- As a general rule, 2 minutes should be spent on each slide, so calculate how many slides you should ideally have.

Identify your audience

- For each type of audience, you will have to vary your content and delivery.
- Once you've identified your audience, elaborate on the key message of your talk with appropriate supporting details and data. Prepare your slides (or other visual aids) to support your words.

Effective Presentation

- **Rehearse your presentation out loud**
- Practice your talk in front of a few fellow students or other trusted colleagues.
- Ask your colleagues for their comments and honest assessment of your performance at the end of the presentation.

Giving the presentation

- Clear presentations usually follow a standard formula:

In a sentence or two, tell the audience what you are going to tell them.

Tell them in detail.

At the end of the talk, tell them what you have told them.

Giving the presentation

- Keep to your allotted time.
- If you've been given 15 minutes for your talk, then talk for 15 minutes.
- A good exercise is to try to anticipate the questions you may be asked and prepare the answers in advance.
- it's always a good idea to repeat it to make sure everyone has heard it properly. That will also give you time to formulate an answer.

Tips for a perfect delivery

- Public speaking is an art.
- During your presentation your voice, facial expressions, and body language are your most important attributes.

Be conscious of how you use your voice.-Don't rush.

Pause at key points to allow the audience to absorb your words.

Look at the audience throughout your talk.

Be receptive to the audience.

Common mistakes

- *Look how much work I've done!*
- Keep your talk short, simple, and to the point.
- Avoid: blocking the screen with your body.
- Avoid: gesturing excessively with your hands or fidgeting.
- Avoid: mumbling and turning your back to the audience.
- Avoid: reading from your slides word for word.
- Finally, no matter how nervous you may feel, relax, and try to look like you're having the time of your life.

Getting Started

- Create a slide show with storyboards, not a script
- To select a design, ask yourself:
  - What professional image do I want to project?
  - In what type of room will I give my talk?
    - Well-lit room: use light background / dark text and visuals
    - Dimly-lit room: use dark background / light text and visuals

Font

- Serif: easy to read in printed documents
  - Times New Roman, Palatino, Verdana
- Sans serif: easy to see projected across the room
  - Arial, Helvetica, Geneva

Displaying Text

- Use bullets
- Use short phrases
- Use grammatical parallelism

Not THAT kind of bullets!!! Let me explain . . .

Use Bullets: Tips

- Bullets help audience skim the slide
- Bullets help audience see relationships between information points

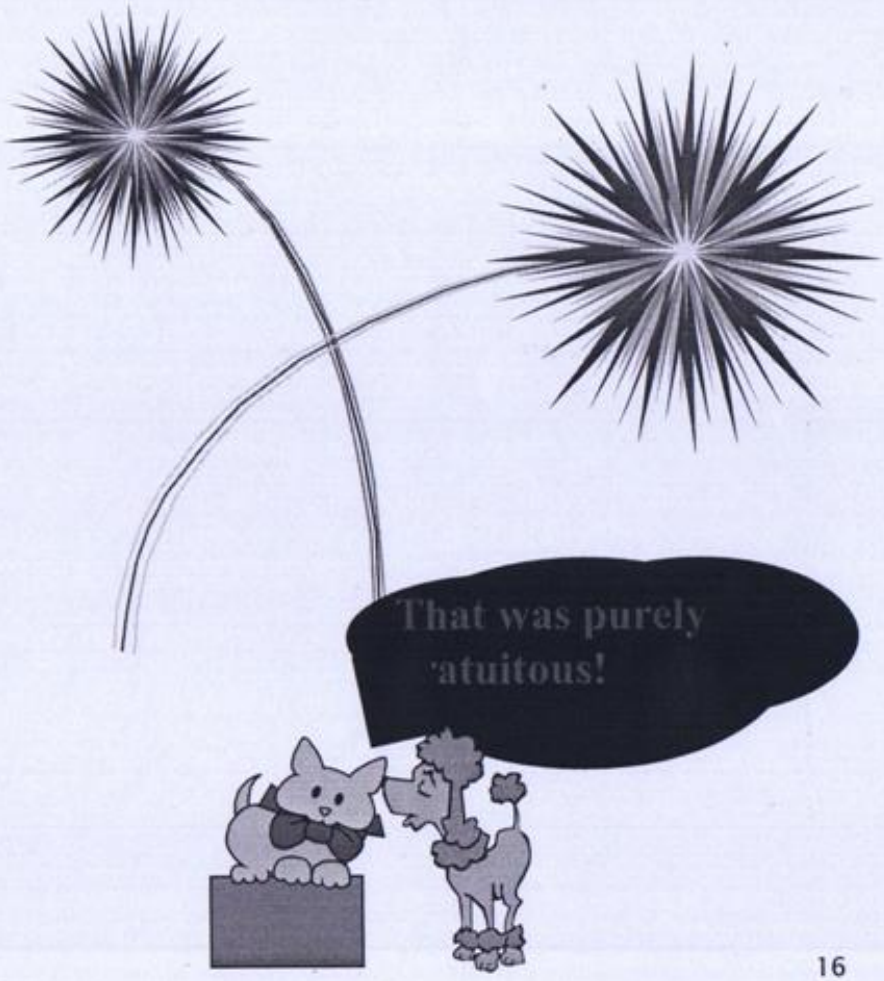
- For example, this is Main Point 1, which leads to...
  - Sub-point 1
  - Sub-point 2

Displaying Visuals: Tips

- Select visuals purposefully
  - What visuals illustrate a point? Make a claim? Help to prove an argument?
- Design easy-to-read visuals
  - Are the visuals easy to read by all members of your audience?
- Draw attention to aspects of visuals
  - How will you draw attention to certain features of the visual?

Displaying Visuals

- Insert <u>needed</u> visuals
- Use color
- Resize appropriately
- Draw attention

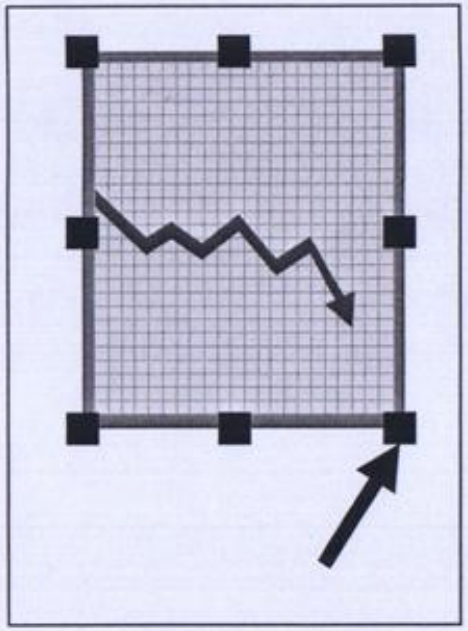


Insert Visuals

- Insert images using "Insert" then "picture"
- Decide whether the image you wish to insert is "clip art" or from a "file" (on disk or on hard drive)

Resize Images: How to . . .

- Click on the visual you wish to resize
- Go to "format" and then "object" or "autoshape"
- Select "size"
- Change size and scale
- OR simply click and drag the corners of the image



Animating: Tips

- Custom animation allows you to animate text, visuals, or line work
- Custom animation should be used purposefully (and sparingly!)
  - Animating should help audience comprehend your message
  - Don't animate solely for aesthetic purposes

Delivery

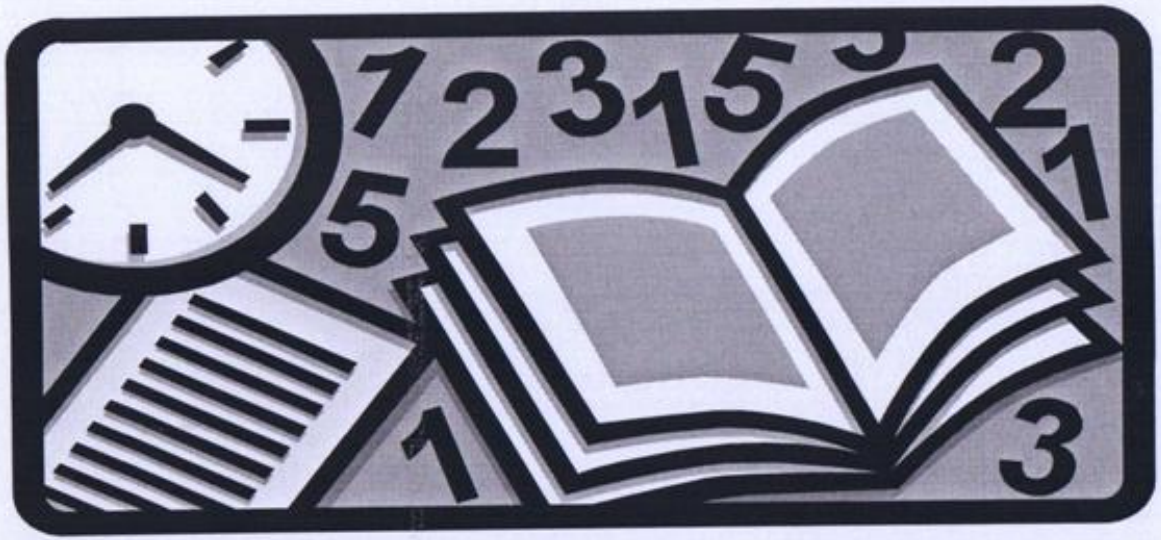
- Adapt to Physical, Cultural Environment
- Stance
  - Body language
  - Handling notes
- Gestures
- Eye contact
- Voice quality
  - Volume
  - Inflection
  - Pace

See evaluation form at http://[illegible].owlnet.rice.edu/~cainproj/

Handling questions

- **LISTEN**
- **Repeat or rephrase**
- **Watch body language**
- **Don't bluff**

Prepare & practice!



Presentation

- PPT- You can use PPT for Presentation.
- You can use Video to present your findings.
- You can use Social media tools to present your work.

Tools

- Prezi.
- Microsoft Power Pont
- Slideshare
- PowToon
- Magisto

Share your work:

YouTube
Dailymotion
Facebook
Twitter

Links

- https://www.youtube.com/watch?v=HAnw168huqA
- https://www.youtube.com/watch?v=EQNpMYKNk1A
- https://www.youtube.com/watch?v=ENJ8vOVlKfs