FORMULATING AND TESTING HYPOTHESIS

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CHAPTER – 4

FORMULATING AND TESTING HYPOTHESIS

Topics Covered

4.1 DEFINITION OF HYPOTHESIS

We cannot take a single step forward in any inquiry unless we begin with a suggested explanation or solution of the difficulty which originated it. Such tentative explanations are suggested to us by something in the subject-matter and by our previous knowledge. When they are formulated as propositions, they are called hypotheses. The hypothesis (plural hypotheses) is a tentative solution of a problem. The research activities are planned to verify the hypothesis and not to find out the solution of the problem or to seek an answer of a question. It is very essential to a research worker to understand the meaning and nature of hypothesis. The researcher always plan or formulate a hypothesis in the beginning of the problem.

The word hypothesis consists of two words: Hypo + thesis = Hypothesis. 'Hypo' means tentative or subject to the verification and 'Thesis' means statement about solution of a problem. The word meaning of the term hypothesis is a tentative statement about the solution of the problem. Hypothesis offers a solution of the problem that is to be verified empirically and based on some rationale. Another meaning of the word hypothesis which is composed of two words – 'Hypo' means composition of two or more variables which is to be verified. 'Thesis' means position of these variables in the specific frame of reference. This is the operational meaning of the term hypothesis. Hypothesis is the composition of some variables which have some specific position or role of the variables i.e. to be verified empirically. It is a proposition about the factual and conceptual elements. Hypothesis is called a leap into the dark. It is a brilliant guess about the solution of a problem.

A hypothesis is a tentative statement about the relationship between two or more variables. A hypothesis is a specific, testable prediction about what you expect to happen in your study. To be complete the hypothesis must include three components - • The variables; • The population; and • The relationship between the variables. Remember, a hypothesis does not have to be correct. While the hypothesis predicts what the researchers expect to see, the goal of research is to determine whether this guess is right or wrong. When conducting an experiment, researchers might explore a number of different factors to determine which ones might contribute to the ultimate outcome. In many cases, researchers may find that the results of an experiment do not support the original hypothesis. When writing up these results, the researchers might suggest other options that should be explored in future studies.

Examples

A research hypothesis is a prediction of the outcome of a study. The prediction may be based on an educated guess or a formal theory. Example 1 is a hypothesis for a nonexperimental study.

Example 1: It is hypothesized that first grade girls will show better reading comprehension than first grade boys.

In Example 1, the author is predicting that s/he will find higher comprehension among girls than boys. To test it, a nonexperimental study would be appropriate because nothing in the hypothesis suggests that treatments will be given.

A simple research hypothesis predicts a relationship between two variables. From your study of variables, it should be clear that the two variables in Example 1 are (1) gender and (2) reading comprehension. The hypothesis states that reading comprehension is related to gender.

Example 2 is a hypothesis for an experimental study.

Example 2: It is hypothesized that children who arc shown a video with mild violence will be more aggressive on the playground than those who are shown a similar video without the violence.

In Example 2, the *independent variable* is violence (mild vs. none), and the *dependent variable* is aggressiveness on the playground.

The hypotheses in Examples 1 and 2 are examples of directional hypotheses. In a directional hypothesis, we predict which group will be higher or have more of something.

Sometimes we have a nondirectional hypothesis. Consider Example 3.

Example 3: It is hypothesized that the child-rearing practices of Tribe A are different from those of Tribe B.

The author of Example 3 is saying that there will be a difference but does not predict the direction of the difference. This is perfectly acceptable when there is no basis for making an educated guess.

Instead of a nondirectional hypothesis, we might state a research purpose. Example 4 shows a research purpose that corresponds to the nondirectional hypothesis in Example 3.
Example 4: The purpose is to explore the differences in childrearing practices between Tribe A and Tribe B.

A research question may also be substituted for a nondirectional hypothesis. Example 5 shows a research question that corresponds to the nondirectional hypothesis in Example 3.
Example 5: The research question is 'How do the childrearing practices in Tribe A and Tribe B differ?'

When using a research question as the basis for research, we usually should be careful not to state it as a question that can be answered with a simple 'yes' or 'no', as is done in Example 6.
Example 6: The question is, 'Do the child-rearing practices in Tribe A and Tribe B differ?'
Example 6 merely asks 'do they differ?' This is not a very interesting research question. Example 5 is superior because it asks *'how* do they differ?'

The choice between a nondirectional hypothesis, a research purpose, and a research question, is purely a matter of personal taste - all are acceptable in the scientific community. Of course, when we are willing to predict the outcome of a study, we should state a directional hypothesis.

4.2 ASSUMPTION, POSTULATE AND HYPOTHESIS

The terms assumption, postulate and hypothesis occur most frequently in the research literature, but are often confused by research scholars. Hence these terms need clear explanation.

Assumption: Assumption means taking things for granted so that the situation is simplified for logical procedure. Assumptions are not the very ground of our activity as the postulates are. They merely facilitate the progress of an agreement a partial simplification by introducing restrictive conditions. For example, the formulas of Statistics and measurement are based on number of assumptions. Assumption means restrictive conditions before the argument can become valid. Assumptions are made on the basis of logical insight and their truthfulness can be observed on the basis of data or evidences. The postulates are the basis and form the original point of an argument whereas assumptions are a matter of choice and less use, we make them more free will and our argument is a general proposition or convention.

Postulate: Postulates are the working beliefs of most scientific activity. A postulate is a statement assumed to be true without need of proof of any kind. A postulate states an assumption that we make about some relationship between objects. For example, we may postulate that $a+b = b+a$. This simply says that if we combine two objects, a and b, the order in which the combination occurs makes no difference in the result. By logical deductions, other statements, called theorems, are derived. From postulates to theorems we are entirely within the realm of ideas. There is no point in asking for experimental proof of deductions. Such a request would be meaningless. The only appeal for proof that is appropriate is entirely within the realm of logic.

Campbell proposed nine postulates. The first three postulates have to do with identities. The next tow postulates have to do with the establishment of order. The last four have to do with additivity.

1. Either $a = b$ or $a \neq b$
   The first postulate establishes the identity of a number. Numbers are identical or they are different.
2. If $a = b$, then $b = a$
   The second postulate states that the relation of equality is symmetrical.
3. If $a = b$ and $b = c$, then $a = c$
   The third postulate expresses in equation form the familiar dictum; things equal to the same thing are equal to one another.
4. If $a > b$, then $b \ngtr a$
   Postulate four points out the relation is asymmetrical.
5. If $a > b$ and $b > c$, then $a > c$

Postulate five is a transitive statement.

6. If $a = p$ and $b > 0$, then $a+b > p$
   Postulate six indicates the possibility of summation. It also implies the fact that the addition of zero leaves a number invariant.
7. $a+b = b+a$
   Postulate seven means that the order in which things are added makes no difference in the result.
8. If $a = p$ and $b = q$, then $a+b = p+q$
   Postulate eight means that identical objects may be substituted for one another in addition.
9. $(a+b) + c = a + (b+c)$
   Finally, postulate nine means that the order of combinations or associations makes no difference in addition.

Hypothesis: A hypothesis is different from both of these. It is the presumptive statement of a proposition which the investigator seeks to prove. It is a condensed generalization. This generalization requires knowledge of principles of things or essential characteristics which pertain to entire class of phenomena. The theory when stated as a testable proposition formally and clearly and subjected to empirical or experimental verification is known as hypothesis. The hypothesis furnishes the germinal basis of the whole investigation and remains to test it out by facts. The hypothesis is based on some earlier theory and some rationale whereas postulates are taken as granted true. An assumption is the assumed solution of a major problem. It may be partially true. The scientific research process is based on some hypotheses. The nature of sciences and mathematics are based on postulates. The statistic is based on some assumptions which are considered approximate science. The assumptions are helpful in conducting a research work in behavioral sciences.

4.3 NATURE OF HYPOTHESIS

The hypothesis is a clear statement of what is intended to be investigated. It should be specified before research is conducted and openly stated in reporting the results. This allows to –
Identify…

- the research objectives;
- the key abstract concepts involved in the research; and
- its relationship to both the problem statement and the literature review.

The following are the main features of a hypothesis –
It…

- Is conceptual in nature.
- Is a verbal statement in a declarative form.
- Has the empirical referent.
- Indicates the tentative relationship between two or more variables.
- Is a powerful tool of advancement of knowledge, consistent with existing knowledge and conducive to further enquiry.
- Can be tested, verifiable or falsifiable.
- Is not moral or ethical questions.
- Is neither too specific nor to general.
- Is a prediction of consequences.
- Is considered valuable even if proven false.

4.4 FUNCTIONS / ROLES OF HYPOTHESIS

A hypothesis, which is a provisional formulation, plays significant role in empirical or socio-legal research. It not only navigates research in a proper direction but also contributes in testing or suggesting theories and describing a social or legal phenomenon.

Role of hypothesis in navigating research: A hypothesis, regardless of its source, states what a researcher is looking for. It also suggests some plausible explanations about the probable relationships between the concepts or variables indicated therein. In fact, it navigates the research. Without it, no further step is possible in empirical research or non-doctrinal legal research. A hypothesis helps the researcher in drawing 'meaningful conclusions' supported by 'relevant' empirical data. A hypothesis serves as a sound guide to: (i) the kind of data that must be collected in order to answer the research problem; (ii) the way in which the data should be organized most efficiently and meaningfully, and (iii) the type of methods that can be used for making analysis of the data.

Role of 'tested' hypothesis: A hypothesis needs to be empirically tested to draw some inferences about the initially posited relationship between the variables indicated in the hypothesis. Therefore, when it is empirically tested (or not), the initially assumed relationship between the concepts or variables, as the case may be, becomes a proved fact. Once a hypothesis is established, it ceases to be a hypothesis.

A hypothesis also performs the following significant functions –

Test theories: A hypothesis, when empirically proved, helps us in testing an existing theory. A theory is not a mere speculation, but it is built upon facts. It is a set of inter-related propositions or statements organized into a deductive system that offers an explanation of some phenomenon. Facts constitute a theory when they are assembled, ordered and seen in a relationship. Therefore, when a hypothesis is 'tested', it not only supports the existing theory that accounts for description of some social phenomenon but also in a way 'tests' it.

Suggest new theories: A hypothesis, even though related to some existing theory, may, after tested, reveal certain 'facts' that are not related to the existing theory or disclose relationships other than those stated in the theory. It does not support the existing theory but suggests a new theory.

Describe social phenomenon: A hypothesis also performs a descriptive function. Each time a hypothesis is tested empirically, it tells us something about the phenomenon it is associated with. If the hypothesis is empirically supported, then our information about the phenomenon increases. Even if the hypothesis is refuted, the test tells us something about the phenomenon we did not know before.

Suggest social policy: A hypothesis, after its testing, may highlight such 'ills' of the existing social or legislative policy. In such a situation, the tested hypothesis helps us in formulating (or reformulating) a social policy. It may also suggest or hint at probable solutions to the existing social problem(s) and their implementation.

The hypotheses play significant role in the scientific studies. The following are some of the important role and functions of the hypothesis -

- Helps in the testing of the theories.
- Serves as a great platform in the investigation activities.
- Provides guidance to the research work or study.
- Hypothesis sometimes suggests theories.

- Helps in knowing the needs of the data.
- Explains social phenomena.
- Develops the theory.
- Also acts as a bridge between the theory and the investigation.
- Provides a relationship between phenomena in such a way that it leads to the empirical testing of the relationship.
- Helps in knowing the most suitable technique of analysis.
- Helps in the determination of the most suitable type of research.
- Provides knowledge about the required sources of data.
- Research becomes focused under the direction of the hypothesis.
- It is very helpful in carrying out an enquiry of a certain activity.
- Helps in reaching conclusions, if it is correctly drawn.

There are five main functions of hypothesis in the research process suggested by Mc. Ashan-

1. It is a temporary solution of a problem concerning with some truth which enables an investigator to start his/her research works.
2. It offers a basis in establishing the specifics what to study for and may provide possible solutions to the problem.
3. Each hypothesis may lead to formulate another hypothesis.
4. A preliminary hypothesis may take the shape of final hypothesis.
5. Each hypothesis provides the investigator with definite statement which may be objectively tested and accepted or rejected and leads for interpreting results and drawing conclusions that is related to original purpose.

4.5 IMPORTANCE OF HYPOTHESIS

Hypothesis as the Investigator's 'Eyes': By guiding the investigator in further investigation it serves as the investigator's 'Eyes' in seeking answers to tentatively adopted generalization.

It Focuses Research: Without it, research is unfocussed research and remains like a random empirical wandering. It serves as necessary link between theory and the investigation.

It Places Clear and Specific Goals: A well thought out set of hypothesis is that they place clear and specific goals before the research worker and provide researcher with a basis for selecting sample and research procedure to meet these goals.

It Links Together: It serves the important function of linking together related facts and information and organizing them into wholes.

It Prevents Blind Research: The use of hypothesis prevents a blind search and indiscriminate gathering of masses of data which may later prove irrelevant to the problem under study.

As a Sort of Guiding Light: A hypothesis serves as a powerful beacon that lights the way for the research work.

George J. Mouley thinks that Hypotheses serve the following purposes –
They…

- Provide direction to research and prevent the review of irrelevant literature and the collection of useful or excess data.
- Sensitize the investigator certain aspects of situation which are irrelevant from the standpoint of the problem at hand.
- Enable the investigator to understand with greater clarity his/her problem and its ramification.

- Serve as a framework for the conclusive - in short a good hypothesis: (a) Gives help in deciding the direction in which he has to proceed. (b) It helps in selecting pertinent fact. (c) It helps in drawing conclusions.

Van Dalen advocates the importance of hypothesis in the following ways -

- Hypotheses are indispensable research instrument, for they build a bridge between the problem and the location of empirical evidence that may solve the problem.
- A hypothesis provides the map that guides and expedites the exploration of the phenomena under consideration.
- A hypothesis pin points the problem. The investigator can examine thoroughly the factual and conceptual elements that appear to be related to a problem.
- Using hypothesis determines the relevancy of facts. A hypothesis directs the researcher's efforts into a productive channels.
- The hypothesis indicates not only what to look for is an investigation but how to obtain data. It helps in deciding research design. It may suggest what subjects, tests, tools, and techniques are needed.
- The hypothesis provides the investigator with the most efficient instrument for exploring and explaining the unknown facts.
- A hypothesis provides the framework for drawing conclusions.
- These hypotheses simulate the investigator for further research studies.

4.6 CHARACTERISTICS OF A GOOD HYPOTHESIS

A good hypothesis must possess the following characteristics –
It…

- is never formulated in the form of a question.
- should be empirically testable, whether it is right or wrong.
- should be specific and precise.
- should not be contradictory.
- should specify variables between which the relationship is to be established.
- should describe one issue only. A hypothesis can be formed either in descriptive or relational form.
- soes not conflict with any law of nature which is known to be true.
- guarantees that available tools and techniques will be effectively used for the purpose of verification.
- should be stated as far as possible in most simple terms so that the same is easily understandable by all concerned.
- must explain the facts that gave rise to the need for explanation.
- should be amenable to testing within a reasonable time.

A 'workable' or 'usable' hypothesis would be the one that satisfies many of the following criteria.
Hypothesis should be conceptually clear: The concepts used in the hypothesis should be clearly defined, not only formally but also, if possibly, operationally. Formal definition of the concepts will clarify what a particular concept stands for, while the operational definition will leave no ambiguity about what would constitute the empirical evidence or indicator of the concept on the plane of reality. Obviously, an undefined or ill-defined concept makes it difficult or rather impossible for the researcher to test hypothesis as there will not be any standard basis for researcher to know the observable facts. However, a researcher, while defining concepts, should use, as far as possible, the

terms that are communicable or definitions that are commonly accepted. It should be stated as far as possible in most simple terms so that it can be easily understandable all concerned. Researcher should not create 'a private world of words'.

Hypothesis should be specific: No vague or value-judgmental terms should be used in formulation of a hypothesis. It should specifically state the posited relationship between the variables. It should include a clear statement of all the predictions and operations indicated therein and they should be precisely spelled out. Specific formulation of a hypothesis assures that research is practicable and significant. It helps to increase the validity of results because the more specific the statement or prediction, the smaller the probability that it will actually be borne out as a result of mere accident or chance. A researcher, therefore, must remember that narrower hypothesis is generally more testable and s/he should develop such a hypothesis.

Hypothesis should be empirically testable: It should have empirical referents so that it will be possible to deduce certain logical deductions and inferences about it. Therefore, a researcher should take utmost care that his/her hypothesis embodies concepts or variables that have clear empirical correspondence and not concepts or variables that are loaded with moral judgments or values. Such statements as 'criminals are no worse than businessmen', 'capitalists exploit their workers', 'bad parents beget bad children', 'bad homes breed criminality', or 'pigs are well named because they are so dirty' can hardly be usable hypotheses as they do not have any empirical referents for testing their validity. In other words, a researcher should avoid using terms loaded with values or beliefs or words having moral or attitudinal connotations in his hypothesis.

Hypothesis should be related to available techniques: Researcher may ignorance of the available techniques, makes him/her weak in formulating a workable hypothesis. A hypothesis, therefore, needs to be formulated only after due thought has been given to the methods and techniques that can be used for measuring the concepts or variables incorporated in the hypothesis.

Hypothesis should be related to a body of theory or some theoretical orientation: A hypothesis, if tested, helps to qualify, support, correct or refute an existing theory, only if it is related to some theory or has some theoretical orientation. A hypothesis imaginatively formulated does not only elaborate and improve existing theory but may also suggest important links between it and some other theories. Thus, exercise of deriving hypothesis from a body of theory may also be an occasion for scientific leap into newer areas of knowledge.

A hypothesis derived from a theory invests its creator with the power of prediction of its future. The potency of hypothesis in regard to predictive purpose constitutes a great advancement in scientific knowledge. A genuine contribution to knowledge is more likely to result from such a hypothesis. A hypothesis, it is said, to be preferred is one which can predict what will happen, and from which we can infer what has already happened, even if we did not know (it had happened) when the hypothesis was formulated.

4.7 ORIGINS / SOURCES OF HYPOTHESIS

Hypotheses are originated from essentially the same background that serves to reveal problem. These sources are namely theoretical background, knowledge, insight and imagination that come from instructional program and wide reading experiences, familiarity with existing practices. The major sources of hypotheses are given below-

- Specialization of an educational field.
- Published studies, abstracts research journals, hand books, seminars on the issue, current trends on the research area.

- Instructional programs persuaded.
- Analyze of the area studied.
- Considering existing practices and needs.
- Extension of the investigation.
- Offshoots of research studies in the field.

Researcher employs these sources for formulating hypotheses of his/her investigation. S/he has to use two logical processes to drawn upon in developing a hypothesis. The processes are known as - (a) Deductive thinking, and (b) Inductive thinking.

Deduction is a process which goes from the general to the specific. In deduction, general expectations about problems or events based on presumed relationships between variables are used to arrive at more specific expectations. Induction is a process which goes from the specific to the general. In the induction process researcher starts with specific observations and combines them to produce a more general statement of relationship namely a hypothesis. Many researchers begin by searching the literature for relevant specific findings in order to induce a hypothesis, and other often run a series of exploratory studies before attempting to induce a hypothesis. Induction begins with data and observations or empirical events and proceeds toward hypothesis and theories, while deduction begins with theories and general hypothesis and proceeds towards specific hypothesis.

A hypothesis or a set of hypotheses may originate from a variety of sources. The source of hypothesis, however, has an important bearing on the nature of contribution in the existing body of knowledge. A few prominent sources of hypothesis are discussed here below.

Hunch or intuition: A hypothesis may be based simply on hunch or intuition of a person. It is a sort of virgin idea. Such a hypothesis, if tested, may ultimately make an important contribution to the existing science or body of knowledge. However, when a hypothesis is tested in only one study, it suffers from two limitations. First, there is no assurance that the relationship established between the two variables incorporated in the hypothesis will be found in other studies. Secondly, the findings of such a hypothesis are likely to be unrelated to, or unconnected with other theories or body of science. They are likely to remain isolated bits of information. Nevertheless, these findings may raise interesting questions of worth pursuing. They may stimulate further research, and if substantiated, may integrate into an explanatory theory.

Findings of other: A hypothesis may originate from findings of other study or studies. A hypothesis that rests on the findings of other studies is obviously free from the first limitation, i.e. there is no assurance that it may relate with other studies. If such a hypothesis is proved, it confirms findings of the earlier studies though it replicates earlier study conducted in different concrete conditions.

A theory or a body of theory: A hypothesis may stem from existing theory or a body of theory. A theory represents logical deductions of relationship between inter-related proved facts. A researcher may formulate a hypothesis, predicting or proposing certain relationship between the facts or propositions interwoven in a theory, for verifying or reconfirming the relationship. A theory gives direction to research by stating what is known. Logical deductions from these known facts may trigger off new hypotheses.

General social culture: General social culture furnishes many of its basic hypotheses. Particular value-orientation in the culture, if it catches attention of social scientists for their careful observation, generates a number of empirically testable propositions in the form of hypotheses.

Analogy: Analogies may be one of the fertile sources of hypothesis. Analogies stimulate new valuable hypotheses. They are often a fountainhead of valuable hypotheses. Even casual observation in the nature or in the framework of another science may be a fertile source of hypotheses. A proved particular pattern of human behavior, in a set of circumstances or social settings, may be a source of hypothesis. A researcher may be tempted to test these established co-relations with similar attributes in different social settings. Researcher may be interested to test these analogies in a sort of different settings and circumstances. Researcher seeks inspiration for formulating the hypothesis from analogies of others. However, a researcher, when s/he uses analogy as a source of his/her hypothesis, needs to carefully appreciate the theoretical framework in which the analogy was drawn and its relevancy in the new frame of reference.

Personal experience: Not only do culture, science and analogy, among others, affect the formulation of hypotheses. The way in which an individual reacts to each of these is also a factor in the statement of hypotheses. Therefore, individual experience of an individual contributes to the type and the form of the questions researcher asks, as also to the kinds of tentative answers to these questions (hypotheses) that s/he might provide. Some scientists may perceive an interesting pattern from merely seem a 'jumble of facts' to a common man. The history of science is full of instances of discoveries made because the 'right' individual happened to make the 'right' observation because of researcher particular life history, personal experience or exposure to a unique mosaic of events. Researcher personal experience or life history may influence his/her perception and conception and in turn direct quite readily to formulate certain hypothesis.

Thus, a hypothesis may originate from a variety of sources, in isolation or in combination with another. However, in spite of these fertile sources of hypotheses, it is not easy to formulate a usable or workable hypothesis. It is often more difficult to find and formulate a problem than to solve it. If a researcher succeeds in formulating a hypothesis, s/he can assure that it is half-solved. While formulating a hypothesis, researcher has to keep reminding that s/he has to formulate tentative proposition in such a way that it becomes usable in systematic study.

4.8 TYPES OF RESEARCH HYPOTHESIS

Before researchers can begin working on a question that interests them, they need to formulate a research hypothesis. This is an important step in the scientific method because this determines the direction of the study. Scientists need to scrutinize previous work in the area and select an experimental design to use that helps them find data that either supports or rejects their hypothesis. Research hypotheses are of different types: simple, complex, directional, nondirectional, associative, causal, inductive & deductive, null, and alternative or research.

Simple Hypothesis: This predicts the relationship between a single independent variable (IV) and a single dependent variable (DV). For example: Lower levels of exercise postpartum (IV) will be associated with greater weight retention (DV).

Complex Hypothesis: This predicts the relationship between two or more independent variables and two or more dependent variables. Example of a complex multiple independent variable hypothesis - low risk pregnant women (IV) who • value health highly; • believe that engaging in health promoting behaviours will result in positive outcomes; • perceive fewer barriers to health promoting activities; are more likely than other women to attend pregnancy-related education programs (DV). Another example of a complex multiple dependent variable hypothesis - the implementation of an evidence based protocol for urinary incontinence (IV) will result in (DV) • decreased frequency of urinary incontinence episodes; • decreased urine loss per episode; • decreased avoidance of activities among women in ambulatory care settings.

Directional Hypothesis: This may imply that the researcher is intellectually committed to a particular outcome. They specify the expected direction of the relationship between variables i.e. the researcher predicts not only the existence of a relationship but also its nature. Scientific journal articles generally use this form of hypothesis. The investigator bases this hypothesis on the trends apparent from previous research on this topic. Considering the example, a researcher may state the hypothesis as, 'High school students who participate in extracurricular activities have a lower GPA than those who do not participate in such activities.' Such hypotheses provide a definite direction to the prediction.

Nondirectional Hypothesis: This form of hypothesis is used in studies where there is no sufficient past research on which to base a prediction. Do not stipulate the direction of the relationship. Continuing with the same example, a nondirectional hypothesis would read, 'The academic performance of high school students is related to their participation in extracurricular activities.'

Associative Hypothesis: Associative hypotheses propose relationships between variables, when one variable changes, the other changes. Do not indicate cause and effect.

Causal Hypothesis: Causal hypotheses propose a cause and effect interaction between two or more variables. The independent variable is manipulated to cause effect on the dependent variable. The dependent variable is measured to examine the effect created by the independent variable. For the example mentioned, the causal hypothesis will state, 'High school students who participate in extracurricular activities spend less time studying which leads to a low GPA.' When verifying such hypotheses, the researcher needs to use statistical techniques to demonstrate the presence of a relationship between the cause and effect. Such hypotheses also need the researcher to rule out the possibility that the effect is a result of a cause other than what the study has examined.

Inductive and Deductive Hypotheses: Inductive hypotheses are formed through inductively reasoning from many specific observations to tentative explanations. Deductive hypotheses are formed through deductively reasoning implications of theory.

Null Hypothesis: This is a hypothesis that proposes no relationship or difference between two variables. This is the conventional approach to making a prediction. It involves a statement that says there is no relationship between two groups that the researcher compares on a certain variable. The hypothesis may also state that there is no significant difference when different groups are compared with respect to a particular variable. For example, 'There is no difference in the academic performance of high school students who participate in extracurricular activities and those who do not participate in such activities' is a null hypothesis. It asserts that there is no true difference in the sample statistic and population parameter under consideration (hence the word 'null' which means invalid, void, or a mounting to nothing) and that the difference found is accidental arising out of fluctuations of sampling. It is denoted as H_0.

Table 4.1

States of Nature and Decisions on Null Hypothesis

Decision on Null Hypothesis	States of Nature	
	Null Hypothesis True	Null Hypothesis False
Accept	Correct Decision Probability = 1- α	Type II error Probability = β
Reject	Type I error Probability = α (α is called significance level)	Correct Decision Probability = 1- β (1- β is called power of a test)

The rejection of the null hypothesis indicates that the differences have statistical significance and the acceptance of the null hypothesis indicates that the differences are due to chance.

Alternate or Research Hypothesis: This hypothesis proposes a relationship between two or more variables, symbolized as H_1. For example, if a researcher was interested in examining the relationship between music and emotion, s/he may believe that there is a relationship between music and emotion.

H_1 (the research/alternate hypothesis): Music at a fast tempo is rated by participants as being happier than music at a slow tempo.

H_0 (the null hypothesis): Music at a fast tempo and at a slow tempo is rated the same in happiness by participants.

The two hypotheses we propose to test must be *mutually exclusive;* i.e., when one is true the other must be false. And we see that they must be *exhaustive*; they must include all possible occurrences.

Statistical Hypothesis: Statistical hypothesis is an assumption about statistical populations that one seeks to support or refute. The null hypothesis and alternative hypothesis together are called statistical hypothesis.

4.9 USES OF HYPOTHESES IN EDUCATIONAL RESEARCH

The educational researches may be classified into four types: experimental research; normative survey research; historical research; and complex casual research.

- Hypotheses are indispensable for experimental researches. The experiments are conducted to collect empirical data to verify hypotheses. The experimental method or experimental designs are based on hypotheses. Hypotheses are the crucial aspects of such researches.
- In normative survey research the investigator may or may not employ hypothetical type thinking, depending upon the purpose of the research study. Hypotheses are essential for analytical studies and there is little scope in descriptive type studies.
- In historical research the purpose may be either to produce a faithful record of the past events irrespective of present day problem or to extend the experience with phenomena in the present to past in order to make the view of the phenomena. There is a little scope of hypotheses in historical research because hypothesis has the future reference and its verification on empirical data. Case study method has no scope for constructing hypotheses because it is developmental type study.
- In complex casual research the hypotheses have important role in such investigations. These types of studies are conceptual in nature whereas historical are more factual in nature. Therefore formulation of hypothesis is a crucial step of this type of studies.

4.10 FORMULATING HYPOTHESIS

4.10.1 Level of Significance

The level of significance is the probability of rejecting a true null hypothesis that is the probability of "Type I error" and is denoted by α. The frequently used values of α are 0.05; 0.01; 0.1 etc.

When, α = 0.05 it means that level of significance is 5%.

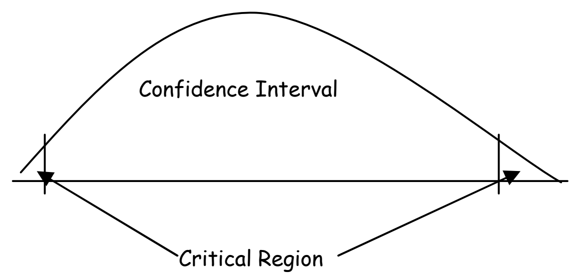
α = 0.01 it means 1% level of significance.

α = 0.01 it means 10% level of significance.

In fact α specifies the critical region. A competed value of the test statistic that falls in the critical region (CR) is said to be significant. So, α is called the level of significance.

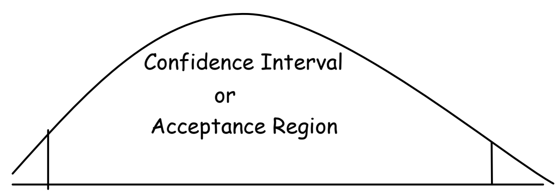
4.10.2 Critical/ Rejection Region

The critical region (CR) or rejection region (RR) is the area under the curve beyond certain limits in which the population value is unlikely to fall by chance only when the null hypothesis is assumed to be true. If an observed value falls in this region H_0 is rejected and the observed value is said to be significant. In a word, the region for which H_0 is rejected is called critical region or rejection region.



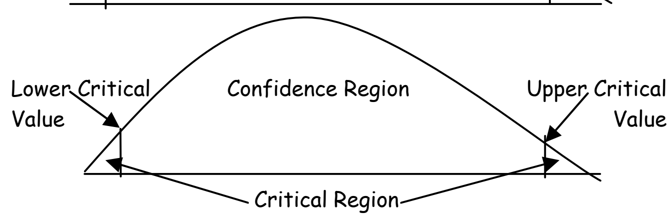
4.10.3 Confidence Interval

Confidence interval is the interval marked by limits within which the population value lies by chance and the hypothesis is consider to be tenable. If an observed value falls in confidence interval H_0 is accepted.



4.10.4 Critical Values

The values of the test statistic which separates critical region from confidence region (acceptance region) are called critical values.

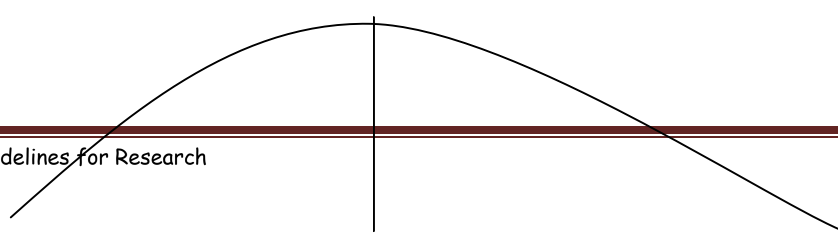


4.10.5 Standard Deviation

The standard deviation is the most frequently calculated measure of variability or dispersion in a set of data points. The standard deviation value represents the average distance of a set of scores from the mean or average score. A smaller standard deviation represents a data set where scores are very close to the mean score (a smaller range). A data set with a larger standard deviation has scores with more variance (a larger range). For example, if the average score on a test was 80 and the standard deviation was 2, the scores would be more clustered around the mean than if the standard deviation was 10.

$$SD = \sqrt{\frac{\Sigma(X-M)^2}{n-1}}$$

Where, SD = Standard Deviation; Σ = Sum of; X = Individual Score; M = Mean of All Scores; n = Sample Size (number of scores).



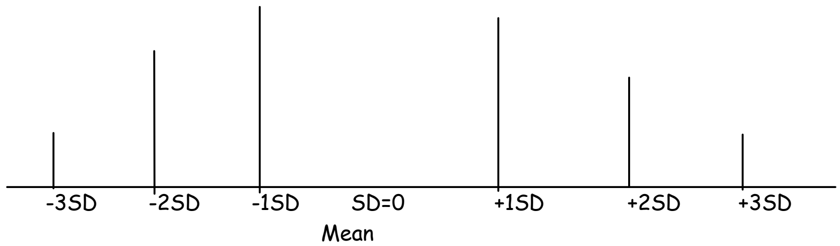


Figure 4.1. Standard Deviation is a Constant Interval from the Mean.

4.10.6 Standard Error

The standard error is an estimate of the standard deviation of a statistic. The standard error is important because it is used to compute other measures, like confidence intervals and margins of error. The standard error is computed from known sample statistics, and it provides an unbiased estimate of the standard deviation of the statistic. Symbolically-

$$S_e = \frac{SD}{\sqrt{N}}$$

Where, *SD* = Standard Deviation; N = Number of Samples.

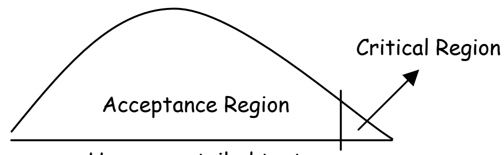
4.10.7 Degree of Freedom

Degree of freedom refers to the number of values which are free to vary after we have given the number of restrictions imposed upon the data. It is commonly abbreviated by *df*. In statistics, it is the number of values in a study that are free to vary. For example, if you have to take ten different courses to graduate, and only ten different courses are offered, then you have nine degrees of freedom. Nine semesters you will be able to choose which class to take; the tenth semester, there will only be one class left to take - there is no choice, if you want to graduate. Degrees of freedom are commonly discussed in relation to chi-square (χ^2) and other forms of hypotheses testing statistics. It is important to calculate the degree(s) of freedom when determining the significance of a chi-square statistic and the validity of the null hypothesis. In chi-square (χ^2) the number of degrees of freedom is described as the number of observations that are free to vary after certain restrictions have been imposed on the data. In a contingency table, the cell frequencies of all columns but one *(c-1)* and of all rows but one *(r-1)* can be assigned arbitrarily and so the number of degrees of freedom for all cell frequencies is *(c-1) (r-1),* where *'c'* refers columns and *'r'* refers rows. Thus in a 2x2 table, the degrees of freedom would be (2-1) (2-1) = 1 and in a 3x3 table, the *df* would be (3-1) (3-1) = 4.

4.10.8 One-tailed and Two-tailed Tests

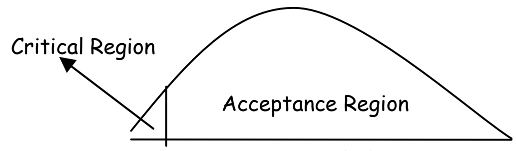
One-tailed Test: A test in which the critical region is located in one tail of the distribution of test of statistic is called one-tailed test. There are two types of one-tailed test in test of hypothesis – (a) Right tailed test and (b) Left tailed test.

A test in which critical region is located in right tail of the distribution of test statistic is called right tailed test or upper one tailed test.



Upper one tailed test

A test in which critical region is located in left tail of the distribution of test statistic is called left tailed test or lower one tailed test.



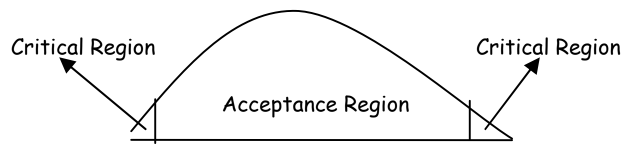
Lower one tailed test

One tailed alternative hypothesis leads to one tailed test. Hypotheses of one tailed tests are –

a. $H_0: \theta \leq \theta_0$
$H_1: \theta > \theta_0$

b. $H_0: \theta \geq \theta_0$
$H_1: \theta < \theta_0$

Two-tailed Test: A test in which the critical region is located in two tails of the distribution of test of statistic is called two-tailed test.



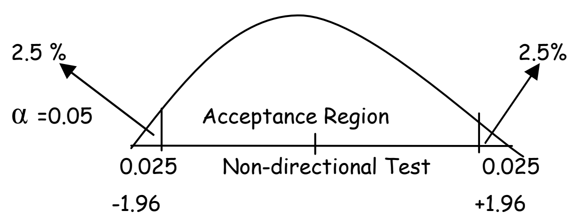
Two-tailed Test

Two-sided alternative hypothesis leads to two-tailed test. The hypotheses are represented as – $H_0: \theta = \theta_0$; $H_1: \theta \neq \theta_0$

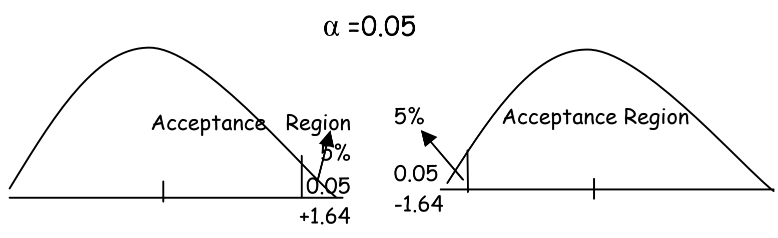
4.10.9 Directional and Non-directional Tests

Non-directional Test: We may wish to test the null hypothesis $H_0: \mu_1 - \mu_2 = 0$ against the alternative $H_1: \mu_1 - \mu_2 \neq 0$. This means that if H_0 is rejected, the decision is that a difference exists between the two means. No assertion is made about the direction of the difference. Such a test is a non-directional test. A test of this kind is sometimes called a two-tailed or two-sided test, because if the normal distribution or the distribution of *t* is used, the two tails of the distribution are employed in the estimation of probabilities.

Consider a 5% significance level. If the sampling distribution is normal, 2.5% of the area of the curve falls to the right of 1.96 standard deviation units above the mean, and 2.5% falls to the left of 1.96 standard deviation units below the mean.



Directional Test: Under certain circumstances we may wish to make a decision about the direction of the difference. If concern with the direction of the difference, we may test the hypothesis $H_0: \mu_1 - \mu_2 \leq 0$



Directional Test

against the alternative $H_1: \mu_1 - \mu_2 > 0$ or the hypothesis $H_0: \mu_1 - \mu_2 \geq 0$ against the alternative $H_1: \mu_1 - \mu_2 < 0$. The symbol H_0 has been used to denote three different hypotheses – (a) a hypothesis of no difference, (b) a hypothesis of equal to or less than, and (c) a hypothesis of equal to or greater than. Such tests are directional one-sided test. If the normal or *t* distribution is used, one side or one tail only is employed to estimate the required probabilities.

To reject H_0: $\mu_1 - \mu_2 \leq 0$ and accept H_1: $\mu_1 - \mu_2 > 0$, using the normal distribution, a normal deviate greater than +1.64 is required for significant at the 0.05 level. Likewise to reject H_0: $\mu_1 - \mu_2 \geq 0$ and accept H_1: $\mu_1 - \mu_2 < 0$, the corresponding normal curve is less than -1.64. The fact that for a normal distribution 5 percent of the area of the curve falls beyond +1.64 standard deviation units above the mean, and 5% beyond -1.64 standard deviation units below the mean.

The choice between a non-directional or directional alternative hypothesis should be determined by the rationale that gives rise to the study and should be made before the data are gathered. The major advantage of a directional alternative hypothesis is that it takes less of a deviation from expectation to reject the null hypothesis.

4.11 TESTING THE HYPOTHESIS

Approaches of Hypothesis Testing: There are three approaches of hypothesis testing (Table 4.2). Each approach requires different subjective criteria and objective statistics but ends up with the same conclusion.

Test Statistic Approach: The classical test statistic approach computes a test statistic from empirical data and then compares it with a critical value. If the test statistic is larger than the critical value or if the test statistic falls into the rejection region, the null hypothesis is rejected.

P-Value Approach: In the *p*-value approach, researchers compute the *p*-value on the basis of a test statistic and then compare it with the significance level (test size). If the *p*-value is smaller than the significance level, researches reject the null hypothesis. A *p*-value is considered as amount of risk that researchers have to take when rejecting the null hypothesis.

Confidence Interval Approach: Finally, the confidence interval approach constructs the confidence interval and examines if a hypothesized value falls into the interval. The null hypothesis is rejected if the hypothesized value does not exist within the confidence interval.

Table 4.2

Three Approaches of Hypothesis Testing

Step	Test Statistic Approach	*P*-Value Approach	Confidence Interval Approach
1	State H_0 and H_1	State H_0 and H_1	State H_0 and H_1
2	Determine test size α and find the critical value	Determine test size α	Determine test size α or 1- α, and a hypothesized value
3	Compute a test statistic	Compute a test statistic and its *p*-value	Construct the (1- α)100% confidence interval
4	Reject H_0 if Test Statistic > Critical Value	Reject H_0 if *p*-value < α	Reject H_0 if a hypothesized value does not exist in Confidence Interval
5	Substantive interpretation	Substantive interpretation	Substantive interpretation

Procedure for/ Steps of Hypothesis Testing: All hypothesis tests are conducted the same way. The researcher states a hypothesis to be tested, formulates an analysis plan, analyzes sample data according to the plan, and accepts or rejects the null hypothesis, based on results of the analysis. The general logic and procedure followed in testing hypothesis comprised the following steps –

1. Assumption: If there are any assumption about the normality of the population distribution equality of variance, independence of samples, etc. they should be stated.
2. State the Hypotheses: Every hypothesis test requires the analyst to state a null hypothesis (H_0) and an alternative hypothesis (H_1). A hypothesis which states that there is no difference

between assumed and actual value of the parameter is the null hypothesis and the hypothesis that is different from the null hypothesis is the alternative hypothesis. The hypotheses are stated in such a way that they are mutually exclusive. That is, if one is true, the other must be false; and vice versa.

3. Set up a Statistical Significance Level: Set the significance level (α) if not already given. α specifies the critical region. Often, researchers choose significance levels equal to 0.01, 0.05, or 0.10; but any value between 0 and 1 can be used.
4. Determination of a Suitable Test Statistic: Test statistic is a formula or function on sample data. A general formula for test statistic –

   $$Test\ Statistic = \frac{Relevant\ (Sample) Statistic - Hypothesized\ Parameter}{Standard\ Error\ of\ the\ Relevant\ Statistic}$$

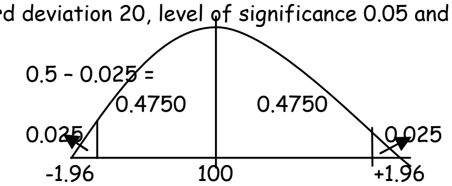
   When the null hypothesis involves a mean or proportion, use either of the following equations to compute the test statistic.

   Test statistic = (Statistic - Parameter) / (Standard deviation of statistic)

   Test statistic = (Statistic - Parameter) / (Standard error of statistic)

   Where, Parameter is the value appearing in the null hypothesis, and Statistic is the point estimate of Parameter.
5. Determine the Critical Region: It is important to specify the acceptance (confidence interval) and rejection (critical) region before the sample is taken, which values of the test statistic will lead to a rejection or acceptance of H_0.
6. Doing Computations: Compute the appropriate test statistic based on sample information.
7. Interpret the Results: Examine whether the calculated test statistic falls in the acceptance or rejection region. If it falls in the rejection region (critical region), the null hypothesis is rejected. If it falls in the accepted region, the null hypothesis is accepted.
8. Making Decision: Make the suitable conclusion for the problem under study.

Example: In a sample study of 64 students are obtained mean 106, standard deviation 20, level of significance 0.05 and H_0:μ = 100. Test the null hypothesis?



Solution

Step 1: Given- Mean, $\overline{x}$ = 106; Standard Deviation, *SD* = 20; N = 64 students.

Step 2: Null hypothesis, H_0: μ = 100; Alternative hypothesis, H_1: $\mu \neq$ 100.

Step 3: Level of significance, α = 0.05

Step 4: $z = \frac{\overline{X} - \mu}{S_e}$

Step 5: Critical region (CR) $z = \pm 1.96$

Step 6: $z = \frac{106 - 100}{Se} = \frac{106 - 100}{2.5} = \frac{6}{2.5} = 2.4$ Where, S_e= Standard Error $= \frac{SD}{\sqrt{N}} = \frac{20}{\sqrt{64}} = \frac{20}{8} = 2.5$

Step 7: The obtained *z*-value 2.4 falls in the critical region (1.96), so the null hypothesis is rejected.

Step 8: Hence, we concluded that there is significant difference.

4.12 STATISTICAL ERRORS IN HYPOTHESIS

In statistical test theory the notion of statistical error is an integral part of hypothesis testing. In an ideal world we would always reject the null hypothesis when it is false, and we would not reject the null hypothesis when it is indeed true. But there are two other scenarios that are possible, each of which will result in an error.

Type I Error: A type I error, also known as an error of the first kind, occurs when the null hypothesis (H_0) is true, but is rejected. It is asserting something that is absent, a false hit. A type I error may be compared with a so-called false positive (a result that indicates that a given condition is present when it actually is not present) in tests where a single condition is tested for. A false positive error, or in short false positive, commonly called a 'false alarm', is a result that indicates a given condition has been fulfilled, when it actually has not been fulfilled. A false positive error is a Type I error where the test is checking a single condition, and results in an affirmative or negative decision usually designated as 'true or false'. The rate of the type I error is called the size of the test and denoted by the Greek letter α (alpha). It usually equals the significance level of a test. In the case of a simple null hypothesis α is the probability of a type I error.

Type II Error: A type II error, also known as an error of the second kind, occurs when the null hypothesis is false, but erroneously fails to be rejected. It is failing to assert what is present, a miss. A type II error may be compared with a so-called false negative (where an actual 'hit' was disregarded by the test and seen as a 'miss') in a test checking for a single condition with a definitive result of true or false. A false negative error, or in short false negative, is where a test result indicates that a condition failed, while it actually was successful. A false negative error is a type II error occurring in test steps where a single condition is checked for and the result can either be positive or negative. The rate of the type II error is denoted by the Greek letter β (beta) and related to the power of a test (which equals $1-\beta$).

Example: As it is conjectured that adding fluoride to toothpaste protects against cavities, the null hypothesis of no effect is tested. When the null hypothesis is true (i.e., there is indeed no effect), but the data give rise to rejection of this hypothesis, falsely suggesting that adding fluoride is effective against cavities, a type I error has occurred. A type II error occurs when the null hypothesis is false (i.e., adding fluoride is actually effective against cavities), but the data are such that the null hypothesis cannot be rejected, failing to prove the existing effect.

Tabularized relations between truth/falseness of the null hypothesis and outcomes of the test-

	Null hypothesis (H_0) is true	*Alternative hypothesis (H_1) is true*
Accept H_1	Type I error (False Alarm)	Correct Decision
Accept H_0	Correct Decision	Type II error (Miss)

Hence, when a statistical hypothesis is tested, there are four possible results –
(a) When we accept H_1 and H_1 is true, this is a correct decision about nature.
(b) When we accept H_0 and H_0 is true, this is also a correct decision about nature.
(c) The acceptance of H_1 when H_0 is true, is called a 'Type I' error. It's incorrect decision about nature.
(d) The acceptance of H_0 when H_1 is true, is called a 'Type II' error. It's also incorrect decision about nature.

In 1948, Frederick Mosteller (1916–2006) argued that a 'third kind of error' was required to describe circumstances he had observed, namely-
Type I error: Rejecting the null hypothesis when it is true.
Type II error: Accepting the null hypothesis when it is false.
Type III error: Correctly rejecting the null hypothesis for the wrong reason.

Type I and type II errors are part of the process of hypothesis testing. Although the errors cannot be completely eliminated, we can minimize one type of error. Typically when we try to decrease the probability one type of error, the probability for the other type increases. We could decrease the value of alpha from 0.05 to 0.01, corresponding to a 99% level of confidence. However, if everything else remains the same, then the probability of a type II error will nearly always increase. Many times the real world application of our hypothesis test will determine if we are more accepting of type I or type II errors. This will then be used when we design our statistical experiment.

4.13 STATISTICAL POWER OF RESEARCH

The power of a statistical test is the probability that it correctly rejects the null hypothesis when the null hypothesis is false. It can be equivalently thought of as the probability of correctly accepting the alternative hypothesis when the alternative hypothesis is true - that is, the ability of a test to detect an effect, if the effect actually exists. If the power increases, the chances of a Type II error occurring decrease. The probability of a Type II error occurring is referred to as the false negative rate (β) and the power is equal to $1-\beta$. The power is also known as the sensitivity.

Table 4.3
Power of a Test

Decision on Null Hypothesis	State of Nature	
	Null Hypothesis True	*Null Hypothesis False*
Accept	Correct Decision Probability = 1- α (Confidence Level)	Type II error Probability = β
Reject	Type I error Probability = α α is called significance level	Correct Decision Probability =$1-\beta$ $1-\beta$ is called *Power* of a test

We have found six factors that affect the power of a test, the probability of rejecting H_0 when it is false. They are –

Discrepancy Between the True Population Mean (μ_{true}) and the Hypothesized Mean (μ_{hyp}): The larger the discrepancy, the greater the power.

Sample Size: Other things being equal, the larger the size of the sample, the smaller the standard error of the mean and the greater the power of the test.

Standard Deviation of the Variable: The smaller the standard deviation, the greater the power. The standard deviation can be reduced by improving the reliability of the measuring instrument.

Relation Between Samples (More Than One Mean): Dependent samples can increase power. In general, the higher the correlation induced by pairing, the stronger the effect on power.

Level of Significance: The larger the value of α, the lower the value of β and the greater the power.

Choice of H_1 : Power is greater for a one-tailed test than for a two-tailed test (when the direction specified by H_1 is correct).

4.14 LIMITATION OF THE TESTS OF HYPOTHESIS

We have some important tests (both parametric and non parametric) often used for testing hypotheses on the basis of which important decisions may be based. But there are several limitations of the said tests which should always be borne in mind by a researcher. Important limitations are as follows-

- The tests should not be used in a mechanical fashion. It should be kept in view that testing is not decision-making itself; the tests are only useful aids for decision-making. Hence, proper interpretation of statistical evidence is important to intelligent decisions.
- Test do not explain the reasons as to why does the difference exist, say between the means of the two samples. They simply indicate whether the difference is due to fluctuations of sampling or because of other reasons but the tests do not tell us as to which is/are the other reason(s) causing the difference.
- Results of significance tests are based on probabilities and as such cannot be expressed with full certainty. When a test shows that a difference is statistically significant, then it simply suggests that the difference is probably not due to chance.
- Statistical inferences based on the significance tests cannot be said to be entirely correct evidences concerning the truth of the hypotheses. This is specially so in case of small samples where the probability of drawing erring inferences happens to be generally higher. For greater reliability, the size of samples be sufficiently enlarged.

All these limitations suggest that in problems of statistical significance, the inference techniques (or the tests) must be combined with adequate knowledge of the subject-matter along with the ability of good judgement.

4.15 CRITERIA FOR EVALUATING HYPOTHESIS

Some hypotheses are considered more satisfactory than others. The following are the serious considerations of a satisfactory hypothesis and these criteria may be helpful to make this judgement.

Plausibility of Explanation: Several criteria are involved in establishing the plausibility of explanations. A satisfactory hypothesis should have relevant and logical possibility about the relationship of variables included in them.

Testability of Explanation: The variables should be defined operationally and the predicted relations among them can be tested empirically. The variables of the hypothesis should be measurable or quantifiable. The suitable measuring instrument is available or it can be considered easily.

Adequacy of Scope: The most useful hypotheses explain all the facts that are relevant to the phenomena being explained and contradict none of them. The broader the scope of a theory, the more valuable it is. The more consequences that a hypothesis yields, the greater is its fruitfulness. A hypothesis is of greater value if it establishes a generalization that can be applied in many areas of education or in many fields. The most satisfactory hypotheses not only explain all the known facts that gave rise to the original problems but also enable scientists to make predictions about as yet unobserved events and relationships.

Usefulness of False Hypotheses: Hypotheses need not be the correct answers to problems to be useful. In almost every inquiry a scholar formulates several hypotheses and hopes that one will provide a satisfactory solution to the problem. By eliminating the false hypotheses one by one the investigator keeps narrowing the field in which the answer must lie. The testing of false hypotheses is also of value if it directs the attention of scientists to unsuspected facts or relations they eventually help in solving the problem.

Roots in Existing Theories: A useful educational hypothesis, therefore, adds something to previously established knowledge by supporting, qualifying, refuting or enlarging upon existing theories. A hypothesis that is compatible with well attested theories is in a favourable position to advance knowledge. If progress is to be made new hypotheses must fit into the framework of existing theories and transform them into more perfect explanatory schemes. Thus, even the more revolutionary theories are not completely different from the existing edifice of knowledge.

Suitability for Intended Purpose: Each hypothesis that offers a satisfactory explanation of what it intends to explain is useful for that purpose. Every hypothesis serves a specific purpose and must be adequate for the purpose it claims to serve. Thus, suitability is also the important criterion for an effective hypothesis.

Simplicity of Explanation: If two hypotheses are capable to explain the same facts, the simpler one is the better hypothesis. Simplicity means that the hypothesis explains the phenomena with the least complexes theoretical structure. The hypothesis that accounts for all facts with the fewest independent or special assumptions and complexities is always preferable.

Levels of Explanation: The value of hypothesis can best be comprehended by tracing their relationship to facts theories and laws. The scientists build gradually a hierarchy of knowledge consisting of (a) hypotheses (b) theories and (c) laws.

- Hypotheses and Facts: A hypothesis is the first step in the direction of scientific truth. In the hierarchy of scientific knowledge it is the lowest on the scale. If empirical evidence can be found to verify the hypothesis, it gains the status of a fact. Thus, a fact is the verified hypothesis.
- Hypotheses and Theories: A theory may contain several logically interrelated hypotheses and postulates may be used as a synonyms for hypotheses. Hypotheses and theories are both conceptual in nature. A theory usually provides a higher level explanation than a hypothesis. A theory presents a comprehensive conceptual scheme that may involve several related hypotheses and explain diverse phenomena, considerable empirical evidences are needed to support it.
- Hypotheses and Laws: Some hypotheses receive sufficient confirmation to lead to the formulation of theories; some lead to the establishment of laws. Laws utilize highly abstract concepts, for they provide the most comprehensive type of explanations. Laws may explain phenomena that have been explained previously by two or three theories. A law retains its lofty scientific status which it claims to explain.

Hence, the basic criteria for evaluating research hypotheses are – (a) stated in declarative form; (b) consistent with known facts, prior research, or theory; (c) logical extension of the research problem; (d) states an expected relationship between two or more variables; (e) can be tested; and (f) is clear and concise.

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