Unit 2

Observation and Experiment

Observation :

An Introduction

Science is primarily based on observation and experiment, guided by reason. Observation and experiment, thus, are two indispensable stages in the formation of any scientific theory. Observation is a procedure whereby senses generate information about an object. It is a process of filtering sensory information. Hearing, sight, smell, taste and touch are the sources of observation and experimentation. It is through these sensory inputs that an inductive generalization is eventually established. Diagrammatically, it can be represented in the following manner:

Meaning of the term 'observation'

The term 'observation' is derived from 'ob' meaning before, and the term 'servare' meaning 'to keep'. Literally speaking, the term means "keeping something before the mind". Thus, the first process in Scientific Method involves the observation of a phenomenon, event or 'problem'. However, it does not mean perceiving things in a careless or casual manner as we do sometimes in our day today life. Observation leads to a question that needs to be answered to satisfy human curiosity about the observation, such as why or how this event happened or what it is like. For example, when I see a shadow passing through my room while I am taking class, I conclude that it must be our watchful school principal who is taking round to see whether classes are being held or not. Later, after the class on examination I find that it was the college electrician who had come to fix fans in the room, seeing room occupied he left in hurry. Thus, careless or casual perception cannot make up for the observation in the strict logical sense of the term.

There is another possibility of error against which we must guard ourselves. Though observation plays a vital role in the formation of scientific laws but all kinds of observation is not our concern. Only those observations excite us intellectually which are worthy of some purpose. My seeing a tall building, hearing an auto sound and other endless observations which I perceive ever since I start my day, do not

serve any purpose as they are routine happenings. In Induction we are concerned with an observation which has a definite purpose, aim or objective. As we have a purpose in those observations, our scientific inquiries proceed without much ado. Such purposive observations involve witnessing both regularities and irregularities and when examined seriously, they lead to successful results. For example, if we wish to ascertain the cause of dengue fever, we observe and examine various cases, separate the common factors from the uncommon ones. In the course of observation we neglect the uncommon factors and concentrate on those common factors and make the generalization that lowering down significantly of platelets in blood due to mosquito bite, is the cause of dengue fever.

Observation must be distinguished from hasty generalization. A single case of observation cannot lead to any generalization. If I see a single case of my friend who dies after taking disprin with soft drink, then I arrive at a generalization that 'disprin when taken with soft drink leads to death', such is an instance of hasty generalization. In hasty generalization we make some observation in haste and draw wrong results; whereas in observation we are very attentive and cautious. Observation necessarily assumes familiarity with lots of empirical data required to form a generalization. Paucity of empirical data makes the observation ineffective and the generalization fallacious. For example, in a dark room I see a shadow of a statute from which I conclude that there is a man in my room. In this case, I do not see a man but someone like a man, someone who shares some of the characteristics of a man. From this seeming similarity I make a generalization and pass a wrong judgement that there is a man in my room. We do the same in the example of mistaking a rope as a snake.

General Principles of Observation

Observation is a mean of discovering underlying assumptions, rules and principles which are important for the process of Induction. Though there is no clear and precise set of rules to be followed in every act of observation, yet some general principles can be stated. These general principles can broadly be classified under three headings:

(i) Intellectual

(ii) Physical

(iii) Moral

(i) This condition requires that the observer must be keen to know the cause of things and its explanation. Just as an appetite for food is natural to the body in the same manner curiosity to know is natural to a healthy sound mind. This desire to know is essential for observation.

(ii) This principle requires that to begin with an observation, the observer must be in possession of normal senses. That is so say, any deficiency in senses hinders observation and makes all explanations incomplete. For example, a blind person cannot make observation about colors or a deaf person cannot make any observation about sounds. This is also true that a

person who is normal can also make errors. Anybody can fall victim to optical illusions. It is a common sight that while sitting in a train which is parked parallel to another train, one sees that this train is moving and the other is still stationary whereas the truth is just the opposite. As normal senses too have limited powers various aids are developed to enhance human powers of observation, such as weighing scales, telescopes, microscopes, X-ray machines etc. The list of accompanying aids is endless and they are still getting added to the existing list.

(iii) This condition is defined as the condition of 'impartiality'. It is difficult to find a perfect person who can make observations, register facts and yet remain unaffected by his own whims and caprices. This moral condition is just an implicit warning to guard against one's own conscious or unconscious beliefs which may not support a theory. Thus, while impartially recording facts we must be careful to avoid the following biases.

(a) Observational bias - It occurs when an observer or researcher looks only in those areas where he finds positive results matching his beliefs. Here it becomes all the more easier to record observations and take investigation in the desired direction. It is also called 'streetlight effect'.

(b) Confirmation bias - It occurs when the observer is biased towards confirming his conscious or unconscious expectations regarding the observations he is making about some phenomenon. In such biases 'we see whatever we expect to see'. Psychologically, it is called confirmation bias.

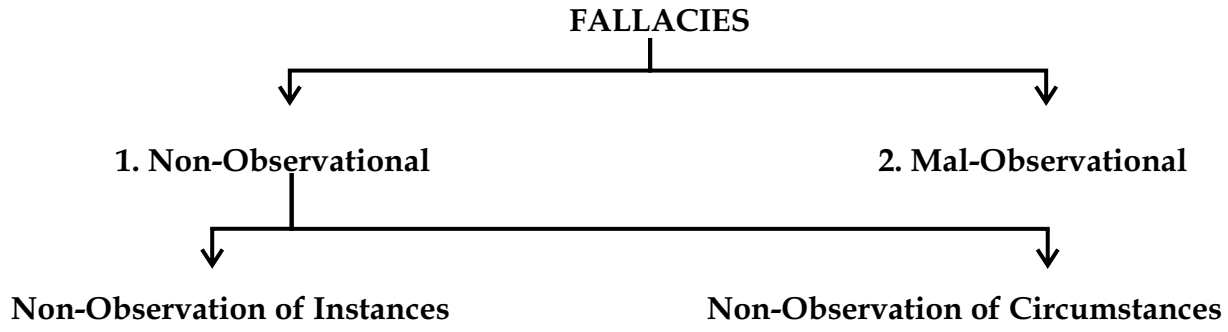
Besides these two major biases there are others also, viz., pathological and processing biases which are concerned with tempering of facts at the observational level and diluting the output. These biases are rampant in pseudo sciences where the correct techniques of science are not followed.

Apart from what has been said so far there are other problems which are encountered so frequently in scientific field. Sometimes observation affects the process being observed so much that it results in a different outcome altogether. For example, it is not possible to check air pressure in an automobile tyre without letting out some of the air, thereby changing the pressure. Further, it is not possible to reduce the importance of observation in favour of some better instrument.

Fallacies of Observation

Scientific theories are primarily tested against observation. Theories are accepted, rejected or modified mainly because of observational data. It is the observational data which provides objectivity to sciences. Its importance can further be gauged when we find that both stability and change in any scientific theory happens because of observation. As we put too much reliance on sensory inputs in observation, we are likely to commit errors. Whenever we commit any error in observation either

because of our over-looking of circumstances or because of some preconceived notions or having some incorrect interpretation, it adversely affects our collection and recording of observational data. Since such errors do affect our observations, they are called observational fallacies. These fallacies are classified as follows:



In the fallacies of non-observation we overlook something which must have been observed. Non-observation can be with regard to particular instances or with regard to particular circumstances.

As far as the non-observation of instances is concerned, we overlook instances which are relevant to the inquiry. This may also happen due to our biases or preconceived notions. For example, in a biased society like ours women are considered to be less superior to man, any inquiry regarding the achievements of women one may overlook several areas where women have made excellent progress. Of recent there was a news item wherein it was told that a man refused to board the aeroplane as it was flown by a woman pilot. This speaks volumes about the deep rooted biases and preconceived notions the community may have towards certain phenomenon.

We also have a natural tendency to overlook those instances which do not support our theory. Sometimes we are attracted towards those impressive reasons other than relevant which suit our theory. Sometimes we look only for positive instances and totally overlook negative instances. At other times weird beliefs and superstitions too play havoc with the outcome of observational data. It is a common sight to find when students do lots of prayers before taking up any examination. It would be nonsensical on the part of any observer who takes this alone to be the criterion for achieving success in examinations.

With regard to non-observation of essential circumstances in our inductive inquiries, we overlook essential conditions which play a vital role. We are not supposed to overlook the circumstances under which the observational study is conducted. It may be the social, political, religious, economical and other reasons which could have made a significant impact on the outcome of the study. The circumstances into which an inquiry is conducted cannot be separated from the observed data. As a

matter of fact, the circumstances and the empirical data are complimentary to each other. No one can be separated or studied in isolation without the other.

To conclude, we may say that observation is an activity of living human beings consisting of receiving knowledge of the outside world through the senses, or the recording of empirical data using scientific instruments.

Experiment

Observation and experiment are two intertwined processes which make inductive generalization possible. In fact, they supply the material ground to induction. An experiment is an observation made under prepared and thus controlled conditions; and when obtainable, it is preferred and finally acquires the honour of a generalization. Formally speaking, an experiment is a methodical procedure carried out with the goal of verifying, falsifying, or establishing the accuracy of a hypothesis. Experiment may vary from an informal to highly formal or controlled conditions. For example, when I lit the match stick by striking on the matchbox, a simple observation shows that the two phenomena are related; it does not show that lightening of the matchstick is dependent on air (oxygen and nitrogen). When the same task is performed under controlled conditions where there is no air, no matter how hard we try there would not be any flame whatsoever. Thus, experiments produce the best results if prepared and conducted carefully. Moreover, conducting of any experiment is possible only when some knowledge is gained through observation. In other words, observation is always prior to conducting of experiments.

An experiment is a controlled manipulation of events, designed to produce observations that confirm or disconfirm one or more rival theories or hypotheses. It is a method of testing - with the goal of explaining- the phenomenon in question. It is also a deciding procedure between two or more competing hypotheses.

Difference between Observation and Experiment

Though both observation and experiment are complementary to each other, yet there are some noticeable distinctions between the two. They (differences) are given below :

1. The first and foremost obvious distinction between the observation and experiment is that the latter is an extension of the former. Experiment not only enables us to produce a much greater number of variations in the circumstances but also produces the sort of variation which is essential for the discovery of some law of the phenomenon. That is why experiment goes much beyond the observable data.

2. In experiment the phenomenon is produced artificially by the researcher whereas in observation phenomenon occurs as an event in the ordinary course of Nature. Through observation we find a fact but through experiment we create a fact. In the case of observation we are at the mercy of

occurrences of phenomena, which are beyond our control. But in the case of experiment we ourselves produce the phenomena and can control the circumstances of their happening.

3. It is also said that observation is natural while the experiment is artificial. This is misleading. In observation, though we depend on Nature for the occurrence of the event but we do sometimes make use of artificial scientific instruments to enlarge and enhance the scope of sense-organs. Similarly experiments are also not totally artificial as we do make use of our natural powers in observing the events produced through experiments.

4. Some people believe that observation is a passive experience while experiment is an active experience. In observation, we watch the event along with its changes which occur in Nature but we cannot make any effort to control them. It is only at level of experiment that we ourselves prepare the conditions under which we control both the event as well as the changes. But it is wrong to suppose that an observer is totally passive while he is observing the event. In fact, an observer has to be very alert while observing the event, its changes and should be able to reject those circumstances which are irrelevant to the phenomenon under investigation. It is equally true that there is greater degree of activity involved in experiments, yet the importance of observation cannot be minimized or underestimated. As a matter of fact, both are corollaries to each other. In the absence of one, the other is futile.

Merits of Experiment over Observation

Direct experiment definitely has advantages over unaided or bare observation. These advantages are as follows :

(a) In experiment there is a possibility of multiplication of instances. This means that if one instance is not sufficient and does not yield the desired results, the scientist can try as many number of times as he wants. While in simple observation we do not have this advantage because we are dependent on Nature, we wait for opportunities. In experiments we create opportunities.

(b) Secondly, in experiments there is a possibility of isolating phenomenon. The observed phenomenon can be isolated in experiments to eliminate or mitigate the influence of those agents which need to be observed again. In observation Nature presents phenomenon in complex surroundings which we cannot ignore or isolate anymore. For example, a candle burns in open air but when put in a closed box, its flame is extinguished. As far as observation goes, it is difficult to find answers. It is only through experiment one finds that flame of the candle lit only when there is air which has nitrogen and oxygen along with many other gases.

(c) Thirdly, experiments are generally created in a comfortable and congenial atmosphere. In observation we are often taken by surprises. For example, when we are to study the causes and

behaviors of earthquakes, we are dependent of Nature. But when we try to study the same phenomenon in a laboratory, we can create conditions and can easily study the phenomenon.

Experimentation is an indispensable step in the Scientific Method that helps us decide two or more competing explanations or hypotheses achieved or arrived at by observation. The two appear different theoretically but practically they are two sides of the same coin. Scientific explanations can be inferred from confirmable data only, and experiments are reproducible and verifiable by other individuals. Together they give rise to good science that is based on information which can be measured or seen and verified by other scientists also.

Questions

1. What is scientific observation? Explain its utility in scientific knowledge.
2. State the general principles (conditions) of good observation.
3. Does observation imply selection and elimination of events? Examine.
4. Discuss the fallacies of observations.
5. Explain the nature and utility of experiments in science.
6. The distinction between experiment and observation is never absolute. Explain.
7. Discuss the advantages of experiments over observations.