Page 10: Hypotheses (Note: Important graphics are missing from these notes.)

Introduction

A hypothesis is a formulation designed to explain observations, and to give a framework for testing. With a hypothesis one begins with evidence and looks for the probable cause. The logical forms discussed in this section is the basis for the "scientific method." This is discussed more at the end of this section. A hypothesis is set up in the following way.

Here are the data (or observations). What could account for this? or What could have caused this?

Reasoning leads me to believe that the most probable cause for these observations is X.

so, If X is the cause, then these observations would follow.

Notice that we now have a hypothetical claim in the standard form, If P, then Q, where P is the probable cause and Q is (are) the observation(s).
Notice also that we are working backwards from the necessary condition to the sufficient condition. In other words the purpose of the hypothesis is to best determine what the sufficient condition is based on what the necessary condition is.

A hypothesis is set up as a conditional claim:

If Hyp., then (O1, O2, ...On).

In words we can say it this way: If my hypothesis is true (i.e., if I correctly identified the sufficient condition) then I'd expect to make these observations.

Notice that because one starts with the observations, that you end up with an argument form like this:

(Missing graphic: See the website.)

Let's use ordinary language to see what's going on. The argument works this way. If my hypothesis is true, then I'd expect to make certain observations. I do make those observations. Therefore, my hypothesis is true.

Okay, except for one thing. Is the conclusion "my hypothesis is true" warranted? No. The reason is that this argument form is fallacious. It is affirming the consequent .

This shows us that the strongest conclusion that can be make is, "My hypothesis is PROBABLY true." (Remember modalities?) This brings us to a very important point:

A hypothesis can never be proved. It can be CONFIRMED or it can be FALSIFIED.

How can it be falsified? Let's suppose that you're doing a scientific experiment. If you do the experiment right, you should get certain results (observations). But you don't get those observations. That argument looks like this:

(Missing graphic: See the website.)

This argument shows that you didn't get the expected observations, so the hypothesis

must be wrong. That is the form modus tollens, which is a valid argument form.

That means your conclusion is certain. The hypothesis is falsified.

It is very important to know that hypotheses end up being one of two argument forms: Affirming the consequent (invalid) when confirmed and modus tollens (valid) when falsified.

Hypothesis, theory, law - What's the difference?

Irving Copi explains this the best;

The vocabulary of "hypothesis," "theory," and "law" is unfortunate, since it obscures the important fact that all of the general propositions of science are regarded as hypotheses, never as dogmas. (Copi, 468)

All hypotheses (including laws and theories) take the logical form discussed above. Scientific theories are designed to give the best explanation. They are probabilistic. So even the law of gravity could theoretically fail tomorrow. It is unlikely, but there is noting that says it must work the same way forever and ever. We think it will, simply because it has done so consistently in the past. This is classic induction. We are predicting future events based on past events, but no future event is logically necessary (not even death and taxes).

Five criteria for evaluating a hypothesis

Because confirmed hypotheses are inductive arguments, their adequacy requires careful consideration.

Relevance
The hypothesis must adequately explain something of significance in a way which matters. For instance suppose my hypothesis is that wicked spirits are making my car run rough. This does not help me solve the problem. It is irrelevant to the problem in that it doesn't get us any closer to solving it than before I developed the hypothesis.

Testability
There should be some way of falsifying the hypothesis. If there is no way to falsify it, then the hypothesis is not much good. The wicked spirit example above is such a case. You can't see wicked spirits, so you can't prove that they aren't causing the engine to run rough. The same is true of many highly regarded scientific hypotheses, like the theory of evolution. It cannot be disproved. These are known as non-falsifiable hypotheses.

Compatibility with Previously Well-Established Hypotheses
A hypothesis should comport with other hypotheses that are solidly confirmed. For instance, the hypothesis about wicked spirits in the engine does not line up well with hypotheses regarding mechanical devices and physics in general.

Predictive or Explanatory Power
A good hypothesis will accurately predict future events. For instance is I have a hypothesis about combining certain chemicals that says that it should cause yellow smoke, then it should actually produce yellow smoke each time it is done in the future.

Simplicity
When comparing several hypotheses which appear to be adequate in terms of the above four criteria, it is good to select the one that does this in the simplest manner. This is not to say that the best hypothesis is simple. It is to say that the hypothesis most likely to be correct is the one which is the least complicated. See Ockham's Razor in the next section.

Ockham's Razor

"Entities are not to be multiplied beyond necessity."

Trivia note: Though this is sound logical advice, it is unlikely that Ockham ever used these exact words. The following words, which communicate essentially the same idea are Ockham's:

"Plurality is not to be assumed without necessity" and "What can be done with fewer [assumptions] is done in vain with more.

Why is it important to understand the logic of hypotheses?

First the good news. The logical system discussed here (the scientific method) is the basis of scientific investigation. The results speak for themselves. Improvements that make life easier, healthier, and safer such as medical advances, farming improvements, manufacturing innovations, transportation advances. The list is almost endless. Of course the scientific method brought us the atom bomb too, but let's not dwell on that.

Now the bad news. The primary limitation of the scientific method is that the answers are never certain. (Remember, a hypothesis can never be proved.) Really, this is a good thing, because it allows for continued research that can give better answers. Unfortunately, many people want to claim that scientific theories are proven, when they are not. How many times have you heard people say, "Evolution is a proven fact"? Evolution is a theory. Logic eliminates the possibility of it ever being proven. Of course the same is true of any competing theory as well. The critical thinker needs to resist being dogmatic about a theory because they prefer it or because a textbook or teacher told them it was true. Science is rarely a field of certainty. It is essential that you keep an open mind to competing theories.

If you rigidly adhere to popular theories, it may turn out that you are like the people who refused to consider that the earth wasn't the center of the universe. They got mad at Galileo, threatened him, and called him nasty things. Now those people look pretty stupid. And it was all because they were closed minded. Don't be like that.

Hypotheses and World Views

Many of our most cherished beliefs, both scientific and nonscientific, are really hypotheses. Some of them are already turning out to be as mythological as the idea that the earth is flat or that use leaches to get rid of diseases. People in fields of science sometimes forget the tentative nature or their profession. The press, politicians, teachers, and students are more likely to forget this. They get the idea that the scientific community has "proved" things which are actually quite debatable. Such things as global warming, the increasing ozone hole, acid rain, and even evolution are theories. All of these theories have serious opponents. Each of these theories has serious problems. None of them has or ever will be proven. And yet, many people consider them unquestioned fact. At best they are tentative - perhaps the best current explanation, but only probable, not certain. Remember, hypotheses are inductive, so the claims must be made with low modalities.

World views are like hypotheses. They are tentative formulations we make of how the world most likely is. We work from our observations of the world, (how those we know interact, how animals behave, what happens when we fall off our bike, what our teachers tell us, what the media tell us, and everything else that we observe), then we develop a hypothesis which most adequately explains those observations. That hypothesis is our world view. Because each individual is limited in their understanding, no one's world view is completely accurate. It is important to realize this in order to be open minded and willing to change your mind when better information comes along. When one is rigid in their world view, they are dogmatic and unteachable. Critical thinkers avoid this. It is good to be aware of the tentative and uncertain nature of hypotheses, both scientific and personal. (See also paradigm)