Baronett, *Logic* (4th ed.)
Chapter Guide

Chapter 14: Causality and Scientific Arguments

Scientific reasoning proceeds on the assumption that there are discernable causal relations between objects and events. What causality is, however, is not as clear as you might think.

A. Sufficient and Necessary Conditions

Understanding causality requires a grasp of the concepts of sufficient and necessary conditions. A **sufficient condition** occurs whenever one event guarantees that another event occurs. A **necessary condition** means that one thing is *essential*, *mandatory*, or *required* for another thing to be realized.

B. Causality

A **cause** can be defined as a condition or set of conditions that bring about an effect. When we talk about a set of conditions, we are talking about a **causal network**.

Establishing the **normal state** of a system helps in defining the **abnormal state** of a system, or any change from the normal state requires an explanation, typically a causal one.

A **precipitating cause** is the object or event directly involved in bringing about an effect. A **remote cause** is something that is connected to the precipitating cause by a chain of events.

C. Mill's Methods

Accurately determining **causes and effects** is not a simple task. We can often confuse the two or misidentify one because we lack sufficient information. Mill's methods are attempts to isolate a cause from a complex event sequence.

1. **Method of agreement**: Two or more instances of an event (effect) are compared to see what they have in common. That commonality is identified as the cause.
2. **Method of difference**: Two or more instances of an event (effect) are compared to see what they all do *not* have in common. If they have all but one thing in common, that one thing is identified as the cause.
3. **Joint method of agreement and difference**: A combination of the methods of agreement and difference, the joint method looks for a single commonality among

two or more instances of an event, and the joint method looks for a common absence of that possible cause.

4. **Method of residues**: all known causes of a complex set of events are subtracted. What is leftover is said to be the cause.
5. **Method of concomitant variations**: correlations between varying events are sought, that is, correspondence in variations between two sets of objects, events, or data.

D. Limitations of Mill's Methods

Mill's methods can only reveal evidence of **probable causes**; they provide no real explanatory power. Discovering instances of causation is an important step in understanding the world—but it is only part of what we need. We also need to understand *how* and *why* particular instances of causation function as they do. Answers to these questions take us beyond being able to identify cause-effect relationships. We must develop theories and hypotheses—the basis of scientific reasoning.

E. Theoretical and Experimental Science

Scientists proceed by developing a **hypothesis** from observed data. A hypothesis is a provisional and testable explanation for facts. **Theoretical scientists** propose hypotheses to explain natural phenomena, while **experimental scientists** conduct tests of those hypotheses.

F. Inference to the Best Explanation

The process whereby a hypothesis is developed is called **abduction**. Inference from facts to an explanation of those facts, particularly where patterns occur, is an abductive inference.

To resolve conflicting inferences for the same facts, we often have recourse to **inference to the best explanation**, which is to say, when the inference is the most probable.

G. Hypothesis Testing, Experiments, and Predictions

Knowledge is expanded when we can verify or falsify a hypothesis. That's because the experimental tests are constructed in such a way that the hypothesis is likely to be a widely applicable explanation of certain facts, rather than an isolated case. This sort of experiment is **controlled**, which means that the experimental setups differ by only one variable (see Mill's method of difference). The **experimental group** is the one that gets the variable, while the **control group** does not.

Causal claims that result from experiments should reflect five criteria:

1. There should be a correlation between cause and effect.
2. The cause should not precede the effect.
3. The cause should be in the proximity of the effect.
4. A set of necessary and sufficient conditions should exist.
5. Alternative explanations should be ruled out.

H. Science and Superstition

One of the main features of scientific methodology is **verification** and **falsifiability**. Recall from Chapter 4 that an appeal to ignorance is made when we infer from a lack of evidence that something is or is not the case. Although there are times when a lack of evidence should result in a judgment that the original claim is unsupported (as in a criminal court), this is not so in scientific practices.

The following requirements are necessary for a fair test of a causal hypothesis:

1. The prediction should be *verifiable*
2. The prediction should *not* be *trivial.*
3. The prediction should have a *logical connection* to the hypothesis.

It is important to remember that the application of the scientific method attempts to confirm or refute a hypothesis; however, this process should always be considered partial and tentative. The weight we give to a confirmation or refutation is never all or nothing. We must accumulate evidence over a long time. If we make mistakes, they will be revealed by the results of repeated experiments.