Analytical Thinking

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As a caricature of great analytical thinking, we consider Sherlock Holmes, the famous literary detective whose combination of sociopathic behavior, high moral standards, and scientific training made him a superhero of analytical thinking. Explicitly, he used the tool of deductive reasoning to analyze a set of facts, while implicitly applying inductive reasoning by accessing his vast knowledge of criminal behavior. He insisted on using data to analyze a problem saying, "It is a capital mistake to theorize before one has data. Insensibly one begins to twist facts to suit theories, instead of theories to suit facts" (Doyle, 2009). Yet, he also understood that facts can be deceiving, "There is nothing more deceptive than an obvious fact" (2009). Then, after solving a problem (crime), Holmes generalized his results creating rules that always held noting that he can "never make exceptions. An exception disproves the rule" (2009). The sociopathic part of Sherlock's character is what allowed him to accept an invalidation of a rule without emotional attachment. Perhaps this is the super part of Sherlock Holmes' superhero status.

Sociopathy is rare, yet the problem-solving power that Sherlock Holmes built can be harnessed by everyone. We begin by understanding the logical structures that he used, namely, inductive and deductive reasoning, abstraction, and generalization.

Logical Statements

To illustrate inductive and deductive reasoning consider the following statement: If a person eats an entire box of Reese's Peanut Butter Cups, then that person will get sick. Note the "if, then" structure of this statement. The "if" part is a premise, the "then" part is a conclusion. Can we say that the statement holds under any circumstance? This would be a *generalization*. Can we *abstract* the statement to say that eating *any* box of candy will make one sick? Suppose we believe both statements are true. How would we test the statement to either support or correct our belief? In general, one gathers some data and reasons deductively or inductively to minimally support their belief. Let's explore each of these ideas in more depth.

Inductive Reasoning

Inductive reasoning is the process of reaching a conclusion by analyzing a sufficient number of cases, each supporting the conclusion. Since we cannot observe all cases, an inductive statement is probable and, therefore, not certain. Additionally, we may have observed that a statement is nearly always true. This is not very precise, but for the purpose of inductive reasoning, we may say the statement is true. For example, if we knew that, on average, only 1 in 1,000,000 individuals got sick after eating a box of Reese's, we might be skeptical of the truth of the statement. On the other hand, if, on average, 9 out of 10 individuals got sick after consuming a box of Reese's, then we are likely to consider the statement true, even though there were some individuals who did not get sick. Either way, data is required to make a determination.

However, Gathering data may not be practical, and even if it is, there may be other underlying issues. In terms of practicality, how many of your friends can you convince to eat an entire box of Reese's Peanut Butter Cups! Even if you do convince your friends to eat all those Reese's, the truth value of the statement entirely depends on a particular person's reaction to a box of Reese's Peanut Butter Cups. This problem opens a can of worms that is solved by applying statistics. For example, perhaps most of your friends have a high tolerance for candy, then again, perhaps not. To handle this variation in candy tolerance, we could carefully design an experiment and collect sufficient data to "prove" statistically that the statement holds generally. This is the stuff of medical and nutritional science.

Deductive Reasoning

Thus far, we have seen that inductive reasoning requires repeated occurrences of the same conclusion under the same premise to prove a statement true. *Deductive reasoning* differs in that it is the process of analyzing the truth value of one or more premises relative to a conclusion. Adding a little context to the statement "if you eat a box of Reese's Cups, then you will get sick" will help illustrate an application of deductive reasoning.

Suppose you walk into your friend's room, and they are lying on the bed moaning that they are sick. You see an empty box of Reese's on their dresser and chocolate and peanut butter all over their hands and face. Besides being a messy eater, you *deduce* that your friend got sick by eating a box of Reese's cups.

The premises in the situation above are first, the box of Reese's on the dresser, and second, the chocolate and peanut butter all over your friends face. These two premises both imply that your friend got sick eating all those Reese's, but the truth of the statement is not necessarily certain.

In a manner similar to the inductive case, there could be other reasons for your friend's sickness. For example, after seeing the box of Reese's, if upon closer inspection, the box was only missing two Reese's cups, then it might be unlikely that the Reese's were to blame for the sickness. For this reason, it is important to remain open to new data when analyzing a particular situation. This provides evidence that combining inductive and deductive reasoning is valuable as an analytical approach.

Summarizing the analytical structures we have discussed thus far, we have deductive and inductive reasoning, abstraction, and generalization. Deductive reasoning uses directly one or more premises to prove the conclusion true or false. Induction uses many examples of the premise holding true, to prove the conclusion is true. Finally, we have abstraction and generalization. We abstract the elements of a particular statement by taking it from the specific to the general. Then, if inductive and/or deductive reasoning proves the abstract statement true, we obtain a generalization.

Real World Application of Analytical Thinking

How do these analytical structures help us in the "real world?" While we cannot abstract and generalize in the real world with exact precision, we can do so on an operational level that is "good enough." For example, suppose we want to reduce homelessness in the state of Utah by adjusting the patterns of action among those individuals experiencing homelessness. Given data that characterizes the movements of such individuals through the network of homeless services, and demographic data about these individuals, one can abstract homeless individual's patterns into a mathematical model that can be tested under various hypotheses.

Such a model would allow policy makers to test ideas to determine their efficacy prior to implementation. This saves the state and therefore the taxpayer money by reducing poor policy decisions and increases the likelihood of helping individuals experiencing homelessness, a win-win, assuming the present data is sufficient for the task.

If the data is insufficient, we might find that our analysis disagrees with the facts. For example, many people have the impression that most individuals experiencing homelessness remain homeless for long periods of time, or that most individuals experiencing homelessness also experience mental illness. Both of these impressions are false. In the first case, the chronically homeless account for approximately 24% of the overall homeless population (Henry et. al., 2017). In the second case, approximately 20-25% of individuals experiencing homelessness also experience mental illness ("National Center for Homelessness," 2009). While both of these are a non-trivial percentage of the overall homeless population, it is at most only 1/4 of the overall population, not a majority. Why do people think this? Perhaps it is because areas with dense homeless populations tend to have individuals who appear to have been homeless for long periods of time and also appear to be mentally ill. This is a misguided application of deductive and inductive reasoning. The only way to correct this intuitive notion is by way of analytical thinking, namely, one must study the homeless population and build statistical tools that can accurately count a population of people who are notoriously difficult to count.

The use of data to correct assumptions and the building of mathematical models illustrate the necessity of analytical thinking in the “real world.” Additionally, applicability of these skills highlights the necessity of analytically trained individuals to do the analysis. This underscores the importance of courses that teach analytical thinking in general education. Even if you are not the individual who invents the mathematical model, if you are working toward solutions for homelessness, it helps to understand why and how the model works. This principle can be generalized to apply to virtually all careers. The world needs more analytical thinkers!

Summary

Throughout this discussion, we defined some of the tools in Sherlock Holmes’ analytical toolbox and discussed an application of these tools. In particular, we defined inductive and deductive reasoning and applied these principles. In the homelessness example, we saw that abstracting structures to obtain general results via inductive and deductive reasoning leads to better policy decisions. Additionally, we saw that applying these tools with insufficient data can lead to misconceptions. Analytical disciplines can help us avoid those misconceptions by teaching us about this kind of thinking. And all of this implies that analytical training is a necessary condition to a quality education.

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