Chapter 2: Two Types of Reasoning

In chapter 1, I mentioned deductive and inductive arguments. This chapter goes into more depth on deductive reasoning in particular, but also provides a contrast with inductive reasoning. Chapters 3 and 4 will go into more depth on deductive and inductive reasoning, respectively.

Recall that deductive arguments are arguments whose conclusions are *certain*. That is, the premises do not provide evidence for the conclusion, but they show that the conclusion must be true. Inductive arguments, by contrast, are all about *probability*. Good inductive arguments provide good evidence/premises to support (not prove) the conclusion.

From the last chapter, you should have a good idea what an argument is, and a decent idea of what an argument is not. Before we get directly into deduction, let's review a bit from the last chapter, in particular recognizing arguments.

Recognizing Arguments (Review)

It should be obvious that a photograph in an ad is not itself an argument for anything. Other times it's more difficult to recognize an argument. Arguments can be hard to recognize because they are surrounded by irrelevant information like value judgments without reasons supporting them, digressions, biases, and other rhetoric (like fallacies, or mistakes in reasoning, which we'll get to later).

The first task of recognizing an argument is to find the conclusion. Remember that conclusion indicators are words like *therefore*, *thus*, *so*, and more. If you see a conclusion indicator, it's most likely the conclusion (but remember that not every argument has a conclusion indicator). Next you find the premises: the reasons that support the conclusion. Then you figure out the way the premises are related to the conclusion. There are also premise indicators, like *because*, *since*, *given that*, and more.

The goal is to get to the point where you are able to look at a few sentences or a paragraph and determine whether it's an argument. Something else to consider is that arguments often have controversial claims (though not always). For example "before Elon Musk took over Twitter there was a bias on the platform against conservatives" sounds pretty controversial in that it is debatable. If someone makes this claim, they better have premises to support it. But if someone says "my car wouldn't start because the battery died" this is just an explanation—assuming that the dead battery has been verified to be the problem. There is no controversial claim; the speaker is explaining why the car didn't start.

But, we should also understand the idea of controversy broadly. Let's say my car doesn't start and I don't know why yet. In this case, I could make an argument that it is probably the battery since I haven't replaced it in a long time. But it could turn out to be something else, like faulty spark plugs. My claim in *this* case that it's the battery is controversial because it is a hypothesis; we don't yet know the cause of the car not starting. Thus, in this case it is an argument as opposed to explanation.

Now, on to deductive reasoning.

Deductive Reasoning

The following is an exercise for understanding deductive arguments. Try to follow the best you can but I will tell you up front that it is pretty difficult to get at first. If you don't get it right away, don't worry, just move on to the next section. It's only one example, and you can still understand deductive reasoning even if you don't fully get it immediately.

Imagine the following scenario. Three prisoners are in a cell: call them prisoners X, Y, and Z. They are friends. There is also a prison guard they talk to from time to time. X can see, Y is blind in one eye, and Z is completely blind. The prison guard brings in a basket along with 5 hats: 2 are red, 3 are white. The guard blindfolds the prisoners, and puts 3 of the 5 hats on their heads, and the other two in the basket. He tells the prisoners that he'll let one go free if they can figure out what color hat is on their head *with certainty* once the blindfold is taken off. This means that it cannot be a guess, even a good guess, or he'll execute them. Even when the prisoners are un-blindfolded, they cannot see the color of their own hats:

- Prisoner X is asked first if he knows with certainty the color of his hat. He says "no."
- Prisoner Y is asked the same. He says "no."
- Prisoner Z is asked the same and he, with certainty, says "White."

How does he know? Before reading on, take a moment to reflect on how prisoner Z, the completely blind one, can know this.

Here's why Z knows. X must not see two red hats on the heads of Y and Z. If he did, he'd know he had a white hat since there are only two red hats, and he would go free. Y knows that X did not see 2 red hats. Thus, he knows that at least 1 of the 2 hats on his and Z's head is white. If both are not red, at least 1 is white. Thus, if Y sees a red hat on Z's head, he knows his must be white. But he could not have seen a red hat since he answered no. Since Y answered no, Z knows that his hat must be white. If it was red, Y would have answered yes. Despite the fact that he is blind, Z knows with certainty that his hat is white.

This is an example of deductive knowledge. Deductive knowledge means that, based on the information given, we know with certainty that something is true. For example, we know that *if* there are 5 hats total and 3 are on the heads of the prisoners, then there *must be* 2 left over in the basket. Just as the blind man knows his hat is white.

Still, we make assumptions about the prisoners and the hats scenario. We assume that the prison guard is not lying and saying there are two red hats when there are three. We also assume that X's and Y's answers are intelligent answers based on the information. But, assuming that these assumptions are true, then certain other things follow: this is how deductive knowledge works.

Many sophisticated electronic devices, in particular computers, run on logical rules/premises known as *code* or a *programming language*. These languages are fundamentally deductive, in that particular operations logically follow from assumed rules or values. So in some sense, computers are logic machines. In the next chapter, we will take a more technical look at deductive reasoning in the form of something known as *truth functional logic*, *formal logic*, or *symbolic logic*. With symbolic logic, we will be turning natural language into a more basic language, much like what is done with a programming language.

Once again, deductive arguments attempt to provide conclusions that follow from given information, conclusions that are *certain*. There are many games (videogames and otherwise) that use deductive reasoning. Usually these are puzzle games. One such game is available as a board game but is also free online: *Mastermind*. With each move one makes in the game, new information is revealed that helps the player to *deduce* the next best move, and so forth. A more elaborate videogame that involves deductive reasoning is *Baba is You*.

Validity

So we know that deductive arguments aim to provide certainty to their conclusions. However, even if a deductive argument aims to do this, it sometimes fails. A deductive argument that successfully does this is said to be *valid*. If a deductive argument aims to do this, but fails, it is *invalid* Here is a technical definition of valid.

> *Valid*: a deductive argument in which it is impossible for the premises to be true while the conclusion is false.

Just so you know, the concept of validity is one of the most misunderstood concepts by undergrads, which can be seen from the fact that much literature in educational theory discusses issues with teaching about validity.[1] So think again, do you really understand validity after reading that definition? Will you be able to apply that understanding on the assessment? Test yourself now by looking at the following two arguments, one of which is valid and one of which is invalid. Which is which?

1)

1. All men are fathers.
2. Clark is a man.

Thus, Clark is a father.

2)

1. In order for my car to start, it must have at least some gasoline.
2. My car has at least some gasoline.

Thus, my car will start.

Number 1 is valid. Although all men are not, in fact, fathers, that is not what matters to validity. If this is not clear, go back to the definition above. The definition basically tells us that an argument is valid when the truth of the premises demonstrates or guarantees the truth of the conclusion. With number 1, if the premises are assumed to be true, then the conclusion follows with certainty. If all men are fathers, and Clark is a man, then he absolutely must be a father; the conclusion is proven by the premises.

In the case of number 2, by contrast, the argument is not valid. This is because, even if the premises are assumed to be true, the conclusion would not follow with certainty. Given those premises, the car could fail to start in another way. Even if the car has gas, it could still not start because, for example, the battery is dead. Thus, this is an invalid argument.

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[1] See for example: Markovits, H., & Lortie-Forgues, H. (2011). Conditional reasoning with false premises facilitates the transition between familiar and abstract reasoning. *Child Development, 82*(2), 646–660.

Notice that even though argument number 2 *could* be seen as an inductive argument since the premises might still be said to support the conclusion, we still consider it deductive based on the intentions of the speaker. Based on the way the argument is presented, the speaker likely intends the argument to be deductive. Thus, determining whether an argument is deductive or inductive depends in part on the intentions of the speaker as well as on the logic of the argument itself.

With deductive reasoning, assuming the truth of the premises is crucial. We assume that the premises are true, even if they are obviously not true. This is to test whether or not it is valid. Note that in a valid argument, the premises do not actually have to be true. The important difference to understand is between *assumed truth* and *actual truth*. We might assume something is true just to see what would happen if it were true. In fact, scientists do this when they ask themselves whether their theories would make sense *if they were* true. For example, Einstein's theory of relativity made predictions about what to expect during an eclipse—in other words, what to expect if the theory *were* true. When Sir Arthur Eddington tested the theory during an eclipse, and observed that light was bent just as Einstein had predicted, the theory of relativity was shown to *actually* be true.[2] Similarly, theologists use deductive reasoning when they argue that, if we assume that God exists, then we would expect the world to behave in particular ways (coherently, for example). Many of you have likely had the experience of assuming there will be traffic when you go on vacation, so you can ensure you get to your destination on time. Even if there is no traffic (that is, even if your assumption is false) it is still clearly useful to make the assumption. Similarly, even if the scientist's theory is false, it is still useful to assume its truth for scientific investigation.

If you're thinking to yourself "Why would I assume something is true if it's not actually true?" then you have not understood the examples above or validity in general. Another way to say all this is the following.

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[2] Retrieved from https://www.wired.com/2009/05/dayintech_0529/

Whether or not an argument is valid is about *form*. Validity is not about content, or the actual truth.

Validity shows us why it's the case that very rational, educated people can disagree. Look at politics, at academia, at religious forums. Very educated people disagree all the time since truth is independent of validity. In fact, as discussed below smart and educated people can disagree over the nature of truth itself! Consider the following arguments dealing with the controversial case of abortion—one argument supports abortion and the other is against abortion.

In Support of Abortion:

> 1. If the Constitution implies that each person has a right to self-determination concerning matters of a person's physical body, then abortion should be legal.
> 2. The Constitution does imply this.
> Thus, abortion should be legal.

Against Abortion:

> 1. If the Constitution grants every person the right to self-determination, then the involuntary termination of life is wrong.
> 2. If the involuntary termination of life is wrong, then abortion should not be legal.
> 3. The Constitution does grant every person the right to self-determination.
> Thus, abortion should not be legal.

The previous arguments are both valid. Assuming that the premises are true, then the conclusion follows with certainty. It's important that you see the validity of the arguments, regardless of whether you agree with one or the other. The conclusions *must* be true if the premises are true. So where does that leave us if both arguments are valid, yet they contradict each other? Well, it brings us to *soundness*, or actual truth.

Soundness and Truth

Throughout the discussion above of validity, you might have been wondering whether there is a method of assessing the actual truth of the premises of a deductive argument. There is! It's called “soundness.” But don’t get too excited, because soundness isn’t as clear cut as validity.

In fact, some find that validity is easier to assess since it has to do only with the formal relation between the premises and conclusion rather than with the actual truth of the premises. Assessing truth is a difficult matter. Before getting directly into soundness, let’s consider truth itself for a bit.

How do we know if something is true? What do we really know? How many of you have left this town, this state, this country? How do you know the other countries exist? Because people tell you? Is a map correct? Is a model of the galaxy and solar system correct? How do you even know that the world is round?

These are questions we don’t often ask ourselves, but they’re relevant here. For philosophers and even scientists, truth is a difficult matter to assess. The Flat Earth Society is a group that believes the earth is flat and not round, and that astronauts never reached the moon (if we can take their claims seriously).[3] If you think this group is wrong, how do you know that it’s wrong? Because historians say so, because scientists say so? How do you know what anything anyone is telling you is true? Ok, so all of these are questions that can drive you crazy, and they are a motivating force behind movies like *The Matrix*, *Dark City*, *The Thirteenth Floor*, *Inception*, and many, many more.

One place to begin investigating truth is *certainty*. Maybe everything that we can be certain of is true? So what, then, can we be certain of?

[3] The flat earth society. (2016, July 17). Retrieved from http://www.theflatearthsociety.org/cms/index.php

The Persian philosopher Avicenna[4] and the French philosopher Rene Descartes[5] were both concerned with finding the ultimate certainty, what they saw as the ultimate truth. Descartes, for example, is famous for saying “I think, therefore I am.” His point is that, aside from our own internal thoughts, everything can be doubted. You might be thinking, “Well the fact that I am reading these words shows that I am certain of reading now.” But the only way you know this is through your senses, and Descartes argued that senses are not a good foundation for certainty since they can deceive us (consider perspective, optical illusions, etc.).

Notice that your knowledge of God, death, souls, and so forth, all came through your senses at some point, typically from other humans. You might be thinking, “But I had a spiritual experience where I saw God” or “I have faith in reincarnation.” Even so, you were told about these metaphysical concepts by parents, priests, other people, etc., *before* you had those experiences or that faith, so you are merely interpreting those experiences through what other people have told you, no? In other words, your belief is highly vulnerable to the confirmation bias, one of the primary cognitive biases as discussed in chapter 1. And if something is likely influenced strongly by bias, can we call it the ultimate certainty? Let me be clear that there is nothing wrong with holding these beliefs, even rationally-speaking, but right now we’re talking about certainty, not faith or likelihood.

What about math? Isn’t that certain? Won’t it always be the case that 2+2=4? No, said Descartes, because it’s possible that there exists an Evil Genius, a being like God who is all powerful and all knowing, but crucially, not all loving. If such a being had such power, but did not love us, then the being could mess with us, perhaps making us believe that 2+2=5 (though Cartesian scholars differ regarding the actual power Descartes said the Evil Genius has).

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[4] Groff, P. S. (2007). *Islamic Philosophy A-Z*. Edinburgh, UK: Edinburgh University Press.
[5] Descartes, R. (1996). *Meditations on First Philosophy*. J. Cottingham (Ed. & Trans.). Cambridge, UK: Cambridge University Press.

To be clear, Descartes' fundamental point—the meaning of "I think, therefore I am"—is the following. Our internal thinking process is immediately accessible to us and, unlike our senses, completely certain. The certainty of our thoughts, according to Descartes, is evidence that we exist, as something. Even if we know nothing else, including about the nature of our own existence, we at least know that we are beings that think. We might be living in a false reality like in *The Matrix*, but we nevertheless know that we are thinking things of some kind.

By the way, even if we doubt that we are thinking, doubting is still thinking, so we are only proving Descartes' point by doubting. To be fair, many have found flaws in Descartes' argument for other, legitimate reasons.[6]

But let's not forget that we are trying to discuss truth, and finding the ultimate certainty was our first attempt. So what do we do then, if the only certainty is that we exist as something? How can we find *any* truth, let alone certain truth?

Truth Beyond Certainty & Paradigm Shifts

When Descartes and Avicenna wrote their arguments about certainty, the scientific method hadn't been fully developed yet. In fact, Descartes himself was attempting to lay a foundation for what would become the scientific method. The scientific method, naturally, seems like the most obvious way of getting at the truth. The method involves falsifiability, logical consistency, predictable observations, repeatable experiments, etc.[7]

Since Descartes, philosophers and scientists have tried to find ways that we can get at the truth, independent of our subjectivity. So even though it's *possible* that we are being deceived about our existence, it is

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[6] See some common criticisms on the Wikipedia page on the topic: Cogito ergo sum. (n. d.). In *Wikipedia*. Retrieved July, 17, 2017, from https://en.wikipedia.org/wiki/Cogito_ergo_sum.
[7] For more on the scientific method, see: Introduction to the scientific method. (July 17, 2016). Retrieved from http://teacher.nsrl.rochester.edu/phy_labs/appendixe/appendixe.html.

unlikely, and if we make the basic assumption that the world around us is real in some sense, then we can learn about that world through the scientific method.

But believe it or not, the scientific method itself has been called into question, most famously by Thomas Kuhn in his book *The Structure of Scientific Revolutions*.[8] Kuhn essentially argued that science has as much do to with power and social relations amongst scientists as it does with finding out the truth—even in hard scientific fields like physics or biology. He argued that science does not progress linearly or rationally. Rational or linear progression suggests that scientists conduct experiments, discover what's true, and move on to the next experiment.

On the contrary, Kuhn argued that science progresses through a series of what he called *paradigm shifts*. By *paradigm* he means an accepted model or mode of thought, which includes not only core beliefs but specific methods for conducting experiments that are generally accepted in a given field of science. For example, some paradigms in the field of sociology allow narratives or first-person accounts as evidence, but paradigms in physics generally do not and instead focus on statistics, computer models, or experimental designs. Earlier paradigms in the field of economics generally saw human beings as perfectly rational agents, but in more current paradigms human beings are treated as *sometimes* rational agents who are subject to cognitive biases.

So how does a paradigm shift or change? Kuhn said it was a complicated process. (See table 1 for an illustration.) For Kuhn it all begins with *normal science*, where the general beliefs and practices of the core paradigm are accepted. New ideas and experiments are generally filtered through the assumptions of the paradigm and not questioned. But then, usually younger scientists, discover *anomalies* in the paradigm. That is, they may find evidence that contradicts the paradigm. At first, the defenders of the original paradigm may be able to deal with these

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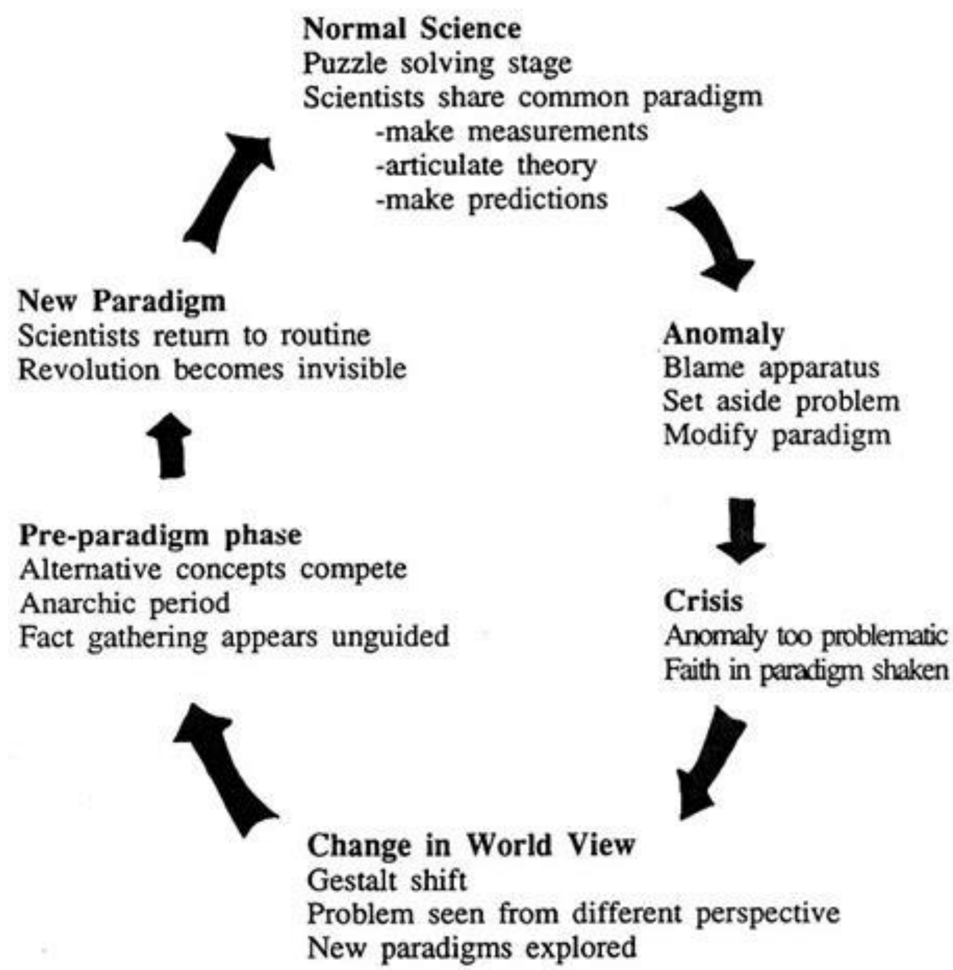
[8] Kuhn, T. (1962). *The Structure of Scientific Revolutions*. Chicago, Il: The University of Chicago Press.

contradictions. They may ignore the problem as an outlier, or may slightly modify the paradigm.

Table 1: Kuhn's Paradigm Shift Model of Science[9]



But then anomalies keep arising to the point that the original paradigm cannot be saved. The evidence against it becomes overwhelming and science enters the *crisis* stage. Sadly, it is usually in this stage that the social element comes in, as the older scientists defending the original paradigm may resort to appeals to authority or personal attacks against the younger scientists. After all, in some cases these older scientists have been working with their paradigm for 30 years or more. So it becomes more personal. If these older scientists are editors of influential

[9] Retrieved from https://faculty.humanities.uci.edu/bjbecker/RevoltingIdeas/week1d.html

publications, they may even elect not to publish articles that contradict the original paradigm. Unfortunately this stage may also involve sexism, racism, and other forms of discrimination.

Still, as Kuhn points out with historical examples, there is eventually a *change in worldview* among the scientific community and new paradigms arise to explain the new evidence. However these paradigms compete with each other, and new social battles between scientists ensue. Although the old paradigm has been overturned, it's not clear yet which new paradigm will replace it. This phase continues to the *pre-paradigm phase*, which Kuhn says is characterized by anarchy in that although experiments are still being conducted and basic facts gathered, it's not clear through which paradigm they should be interpreted.

Eventually, though, a new paradigm is indeed victorious, and a new stage of normal science begins—until more anomalies arise and the process repeats itself. For Kuhn, the history of science is characterized by these paradigm shifts. Crucially, again, it is not linear. And what determines which paradigm is victorious is not necessarily the evidence per se but who has the most prestige in the scientific community.

Another important aspect of Kuhn's theory is *incommensurability*. While minor elements of the original paradigm during a paradigm shift may be preserved, the core assumptions are incommensurable with the new paradigm. For example, the terminology, basic definitions, or accepted types of evidence may be completely incompatible. The other consequence to Kuhn's argument, if he is right, is that scientists never really have the full truth. Because whatever we believe to be true now will be overturned by a future paradigm. He gives the example of a theory from the 19^{th} century that said electricity was a liquid. It was widely believed by most scientists at the time as the proper paradigm in which to understand electricity. Today we understand electricity as more of a force that is part of the broader framework of electromagnetism.

I wish I had easy answers for you here as to what to believe but I don't—and I'm not sure anyone really does (though many may claim to). There are to do this day examples of paradigms that are incommensurable. Some would point to the way quantum mechanics does not fully square with the theory of relativity.[10] Another example is the calorie model of health, which some scientists have argued is outdated and should be replaced by a model that is more consistent with the evidence about exercise, carbohydrates, and more.[11]

Although Kuhn himself denied it, many have argued that his view of science suggests that there is no ultimate truth, since it all boils down to humans' opinions about what theory should be accepted. Relativism comes in different flavors: as you should remember from the first chapter, moral relativism is the view that all values are relative to people and/or cultures. To be a relativist about truth is to believe that truth itself is a matter of opinion.

Many scientists, philosophers, and other academics dismiss objections like Kuhn's to science, arguing that we know science leads to truth because it *works.* After all, what is it that led you to have the amazing, sophisticated machines (computers, smart phones, etc.) that you, like me, likely spend way too much time staring at everyday? Clearly, computers and other advanced technologies are not possible without an understanding of basic physical laws, and this understanding comes from the scientific method.

But as I said, even though we'll largely be ignoring these debates in this class and using a commonsense notion of truth, it's worth going down this path so we have some humility about not just the power of science but about truth in general.

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[10] The physicist Lee Smolin wrote a book on this topic, targeting string theory: Smolin, L. (2007). *The Trouble with Physics*. New York, NY: Mariner Books.
[11] Dunn, R. (2013). Everything you know about calories is wrong. *Scientific American*, *309*(3), 56-59.

Why Truth is (arguably) Still Attainable

Despite all the issues with truth, again, in this class we will use a commonsense notion of truth. The commonsense view does not deny that truth is difficult to understand in some cases (as pointed out by people like Avicenna, Descartes, and Kuhn), but the view nevertheless argues that some claims are more reasonable to believe than others. Based on a commonsense notion of truth, it *is* more reasonable to believe that the earth is round than that it is flat. But let's tie all this truth stuff back to soundness.

> *Sound*: an argument that is valid *and* the premises are true.

In other words, a sound argument has a conclusion that must be true if the premises are true, *but also the premises are actually true*. Because the truth of claims can be debated, the soundness of arguments can be debated too.

If we use a commonsense notion of truth, which of the following valid arguments is sound? (You might also want to make sure you know *why* they are valid.)

1)

> 1. All bachelors are unmarried.
> 2. Jose is a bachelor.
> Thus, Jose is unmarried.

2)

> 1. All women are mothers.
> 2. Carla is a woman.
> Thus, Carla is a mother.

Number 1 is sound (the premises are true) assuming that we know someone named "Jose" who is a bachelor. The first premise "All bachelors are unmarried" is true by definition. Remember, if an argument is sound, it must be valid. But an argument that is valid does not have to be sound. Number 2, for example, is unsound because the first premise is actually false: all women are *not* mothers.

Balance of Considerations and Inference to the Best Explanation

There are two common aspects of general reasoning that we haven't yet discussed: the balance of considerations (BC) argument and the inference to best explanation argument (IBE). A BC is what it sounds like: weighing two options, like making a pro and con list, then choosing the best option. This is a pretty straightforward type of reasoning that you all should be familiar with. Should I eat Chinese or Mexican food for dinner? Should I go to SDSU or UCSD?

An IBE is also what it sounds like. If you are trying to figure something out, and you have some knowledge of the situation, you can attempt to reach the best explanation. If my car won't start, and I know my battery was getting old, the best explanation for my car not starting might be a dead battery. A common IBE people make is that the best explanation for the complexity in the universe is some sort of creator God. Of course, others claim that complexity can be explained just fine without the metaphysical concept of God. There's an interesting debate that touches on this topic (that is, different explanations for the universe) between the physicist Sean Carroll and the theologian William Lane Craig. If you're interested, just google their names and the YouTube video should come up.

Confusions arise because we sometimes mix up BCs and IBEs, which is why the homework focuses on distinguishing the two. Notice that a BC can be either deductive or inductive, depending on the premises we use. For example, the following BC argument is deductive, due to the word "must" in the premises.

1. I must move to one of two places.
2. California is better than Florida.

Therefore, I'll move to California.

But an IBE is usually inductive, since it's the *best* explanation, not the *only* explanation (there are some IBEs that make use of a deductive format). The problem with your car might not be the battery, and the complexity of the universe might be explained without God, or whatever you think explains it. And remember, if there is any doubt about the conclusion given the truth of the premises, it's an inductive, not deductive, argument.

Major Ideas for Two Types of Reasoning

Although anything from the readings or homework might appear on the assessments, the following **major ideas** should be clearly understood.

- Deductive and inductive reasoning
- Validity
- Soundness and truth
  - I think therefore I am, the scientific method, and paradigm shifts
- Balance of considerations (BC) vs. inference to best explanation (IBE)