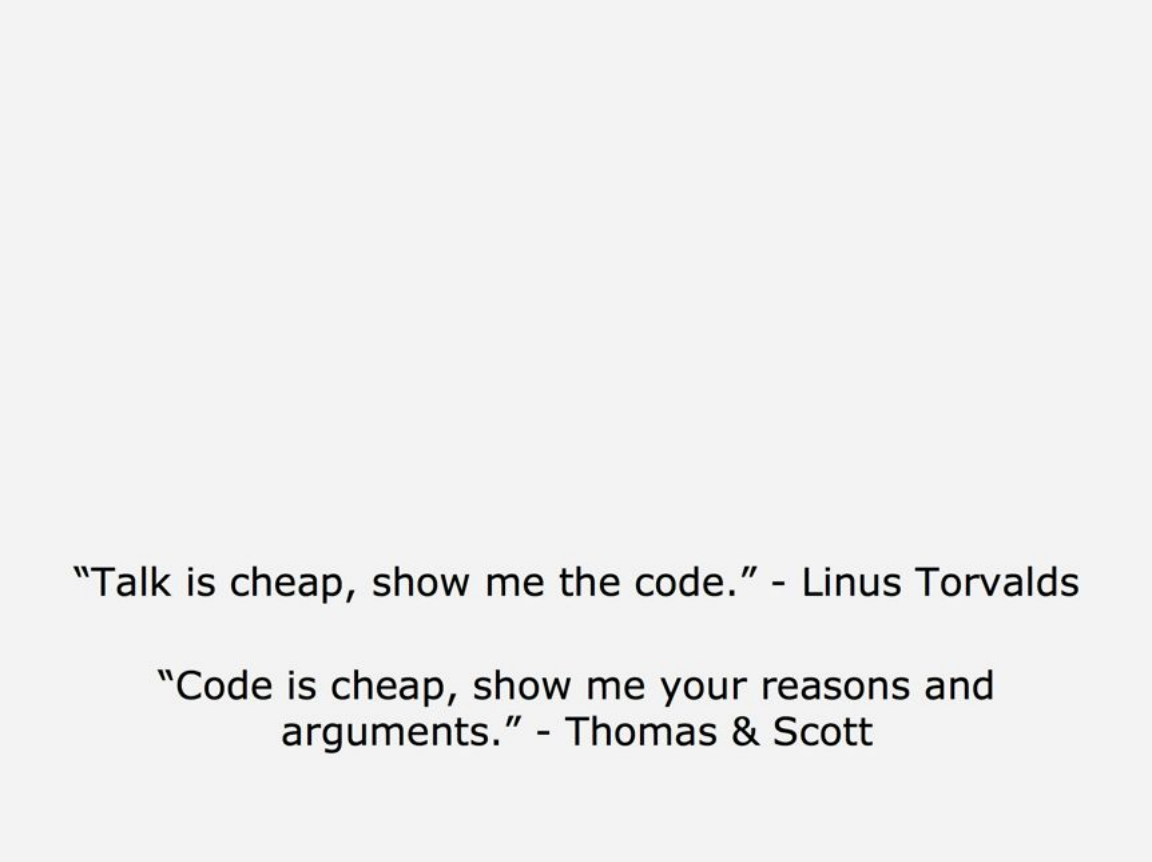
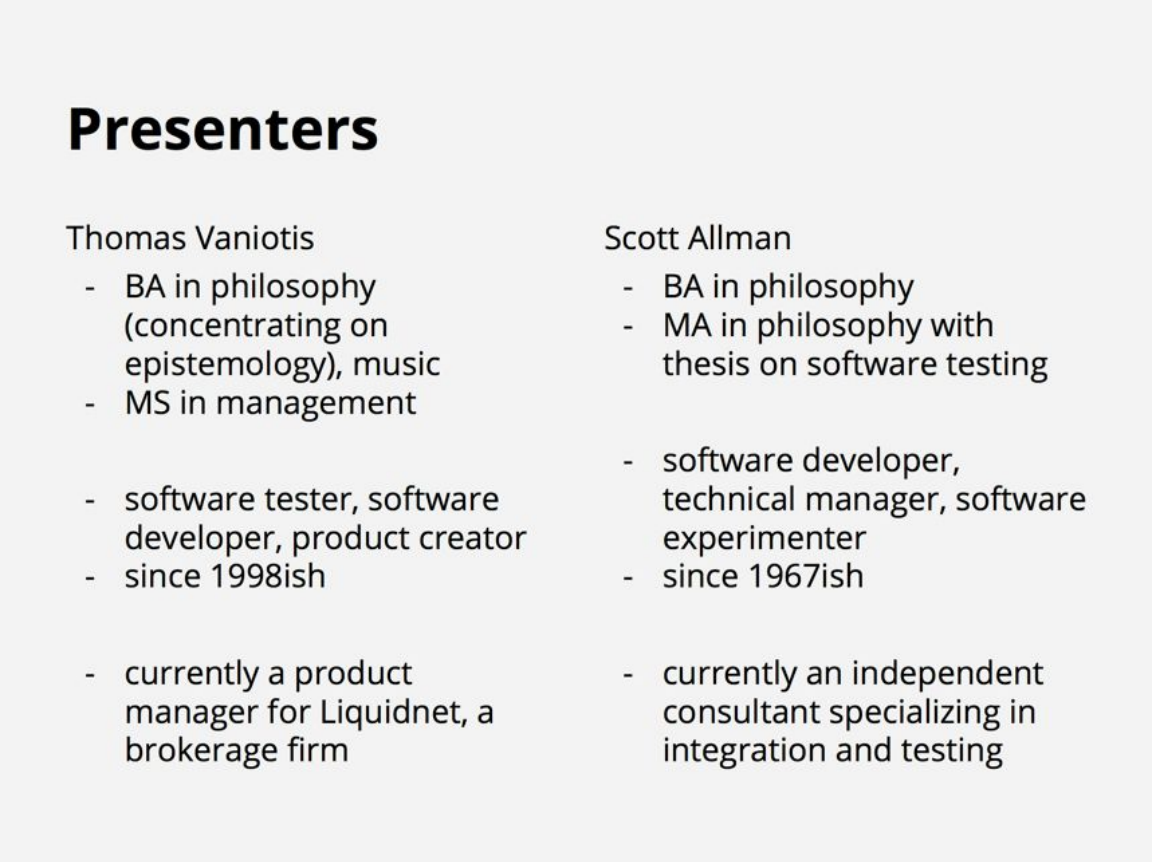
Reason and Argument for Testers

Thomas Vaniotis and Scott Allman, CAST 2015

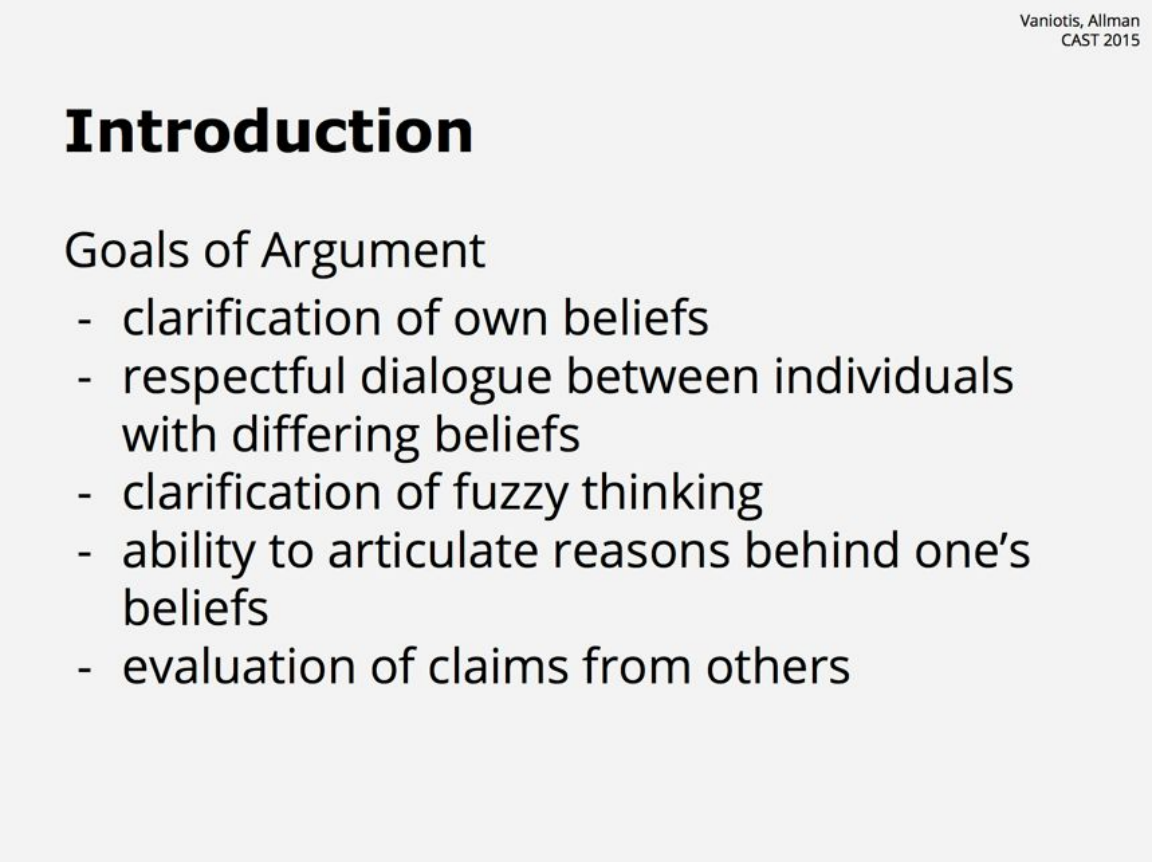


Introduction

We are going to take the unusual technique of reading this paper, instead of speaking from an outline. In our time together, we will introduce you (or re-introduce you) to the analysis and construction of argument, which is typically taught over the course of a first semester of a university philosophy program with lots of one-on-one interaction. We spent a lot of time getting the language in this paper just right to do this precise, technical topic justice in a highly concentrated, CAST-optimized version.



Testers are presented with informal arguments constantly in the course of software development: arguments about their specific test results and work, arguments about the system under test, arguments about the philosophy of testing and development, and so forth. “Argument” in a philosophical sense means a discussion supported by reason and facts in an attempt to arrive at the truth, not the all-too-frequent emotional, animated, and angry exchange of words that “argument” suggests in common discourse (although they sometimes coincide).

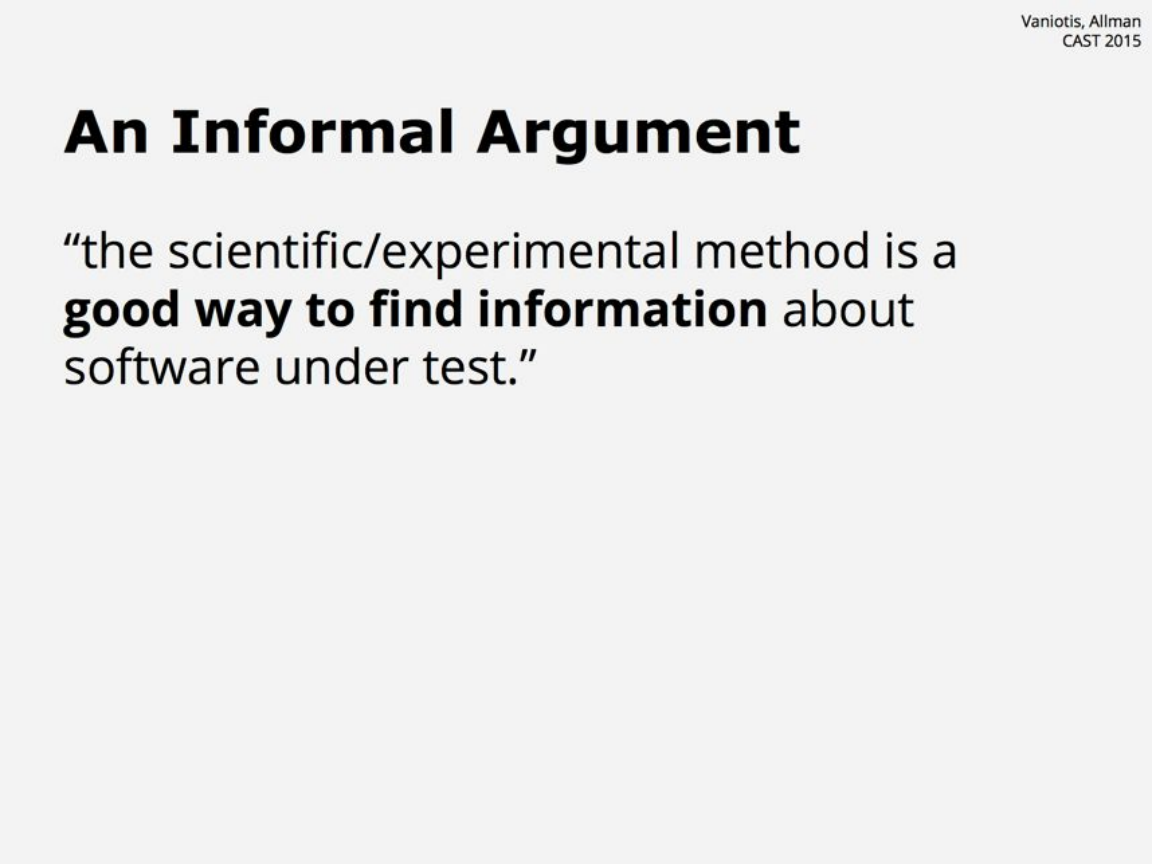


We are going to show you how to use argument as a method for understanding and discovering truth through a formal philosophical framework. By doing so, you should be able to

- understand the reasons behind your beliefs better
- better enter into dialog with others who have different beliefs
- clarify your fuzzy thinking where you have a general sense of the correctness of a belief but are uncertain how to articulate it
- and learn how to evaluate claims from others that you don't already have an opinion on and decide whether to believe them or not.

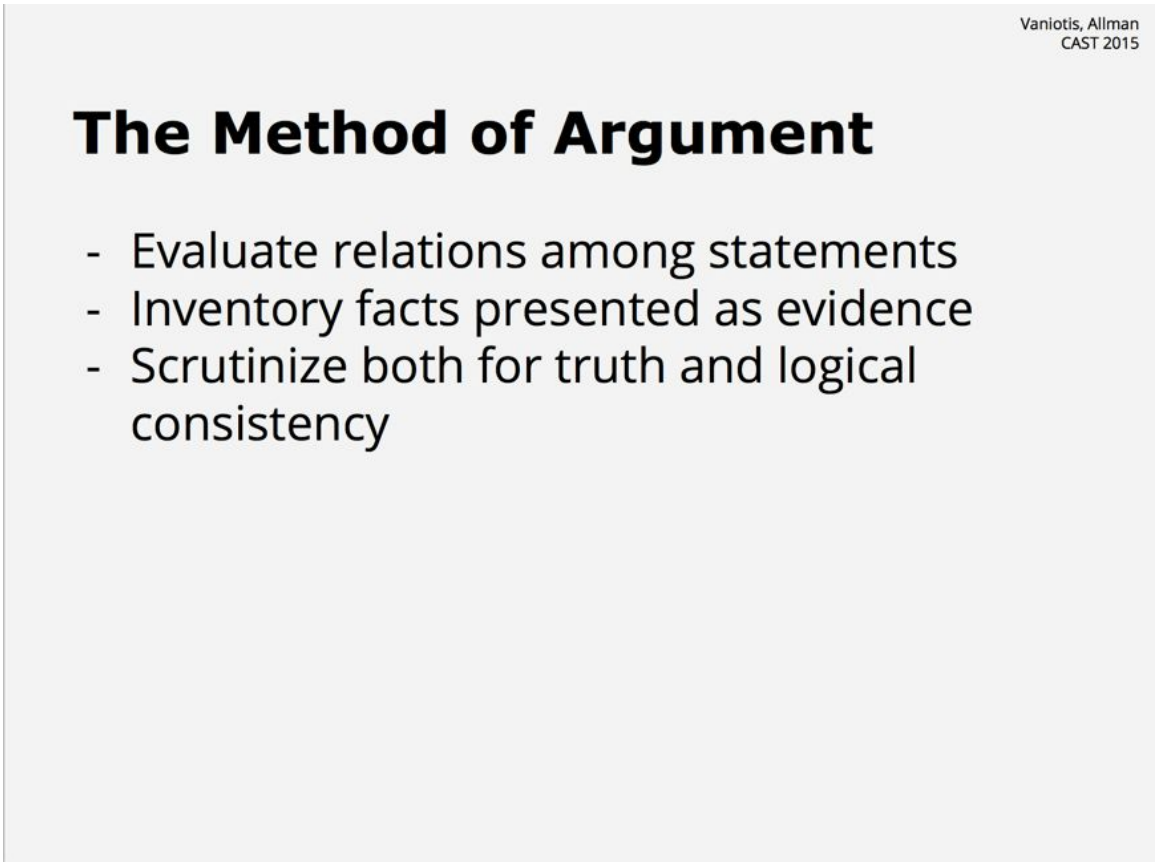
The skill of argument analysis is based on the methods used in Western "analytic" philosophy. We will simplify a few technical points along the way, which may be disappointing to trained philosophers, but we will leave the method intact.

Here is an example of some prose that we might consider as an informal argument:



It has been much remarked in the literature on software testing that "the scientific/experimental method is a good way to find information about software under test." While this is an uncontroversial stance, we note that it relies on a chain of argumentation: (1) first, that the scientific method is a good way to find true information about a certain domain of knowledge (2) second, that the useful information about software that testers wish to find is in that domain.

In the remainder of this presentation, will give you the skills to convert this sort of informal prose argument to a form that can be formally analyzed. We will also examine examples of the formal structure underlying popular software test automation tools. We feel that a healthy combination of theoretical and technical exercises will help you master this skill.

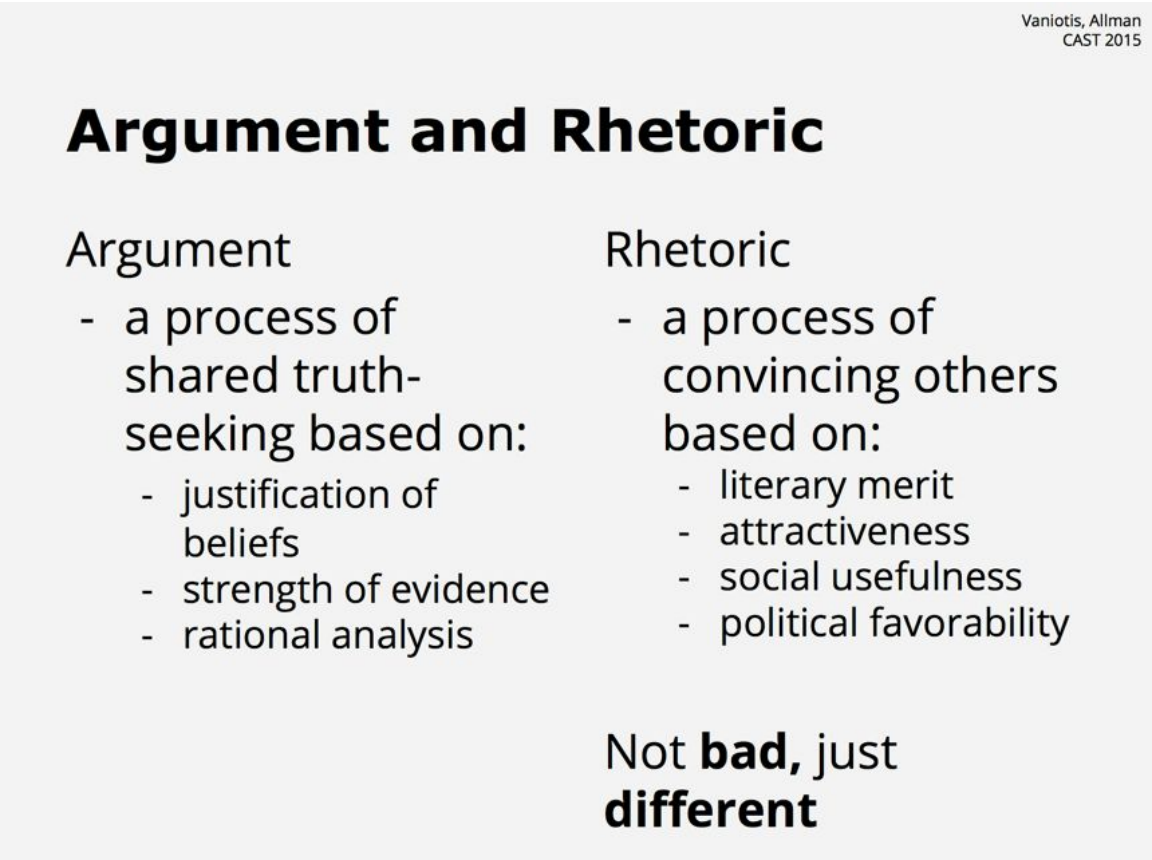


The Method of Argument

In a nutshell, we will guide you through exposing the facts and logic in an argument, hoping to yield a fruitful start to understand and develop the ideas expressed therein.

We will break down the method of argument into a few stages, introducing a more technical vocabulary as we demonstrate each step:

(1) formally evaluating the relations among the statements making up an argument
(2) inventorying the facts lurking in the argument's statements
(3) shining the light of scrutiny on both logical form and facts to evaluate the effectiveness of the argument itself



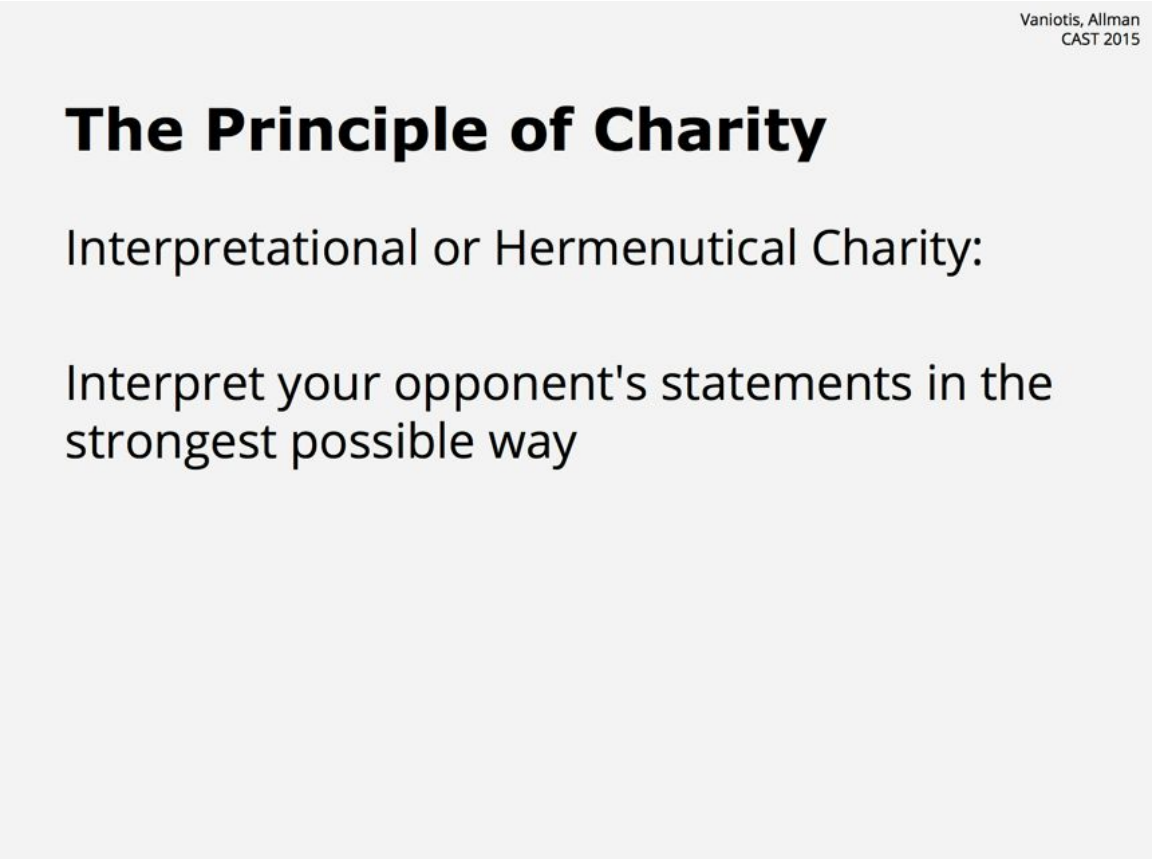
Argument, Rhetoric, and Interpretation

Argument should be carefully distinguished from rhetoric. In everyday speech, we sometimes think of an argument or a verbal debate as a contest of words in which the most skilled debater "wins" by "scoring points" against an opponent. Sometimes we observe a heated emotional exchange in which the participants attempt to influence each other's feelings about a subject. Philosophers categorize these kinds of conversations as "rhetoric", the art of using language to persuade. Effective rhetoric relies on aspects like literary merit, surface attractiveness of presentation, and the usefulness of the speech to advancing a cause. It is an important skill, but we must remember that effective rhetoric can be used to support both true and false beliefs.

By contrast, when philosophers speak about argument (as we will in the remainder of this talk), we are talking about a process of shared truth-seeking. Participants in argument agree to analyze a chain of reasoning and follow it to its conclusion, regardless of their starting positions. They should be open to changing

their beliefs if the evidence warrants. By focusing on the connection between evidence and truth, argument encourages dispassionate discussion, even if the topic is one that inspires passionate feelings. Formal argument does not require us to abandon open-mindedness and tolerance. Those virtues are encouraged by focusing on ideas over presentation and agreeing to pursue evidence and reasoning regardless of personal biases. The method of argument does not guarantee that everyone will come to the same conclusion about every controversial question, but it ensures clarity around the precise points of disagreement and allows participants to maintain friendship and respect for each other.

A Principle of Charity

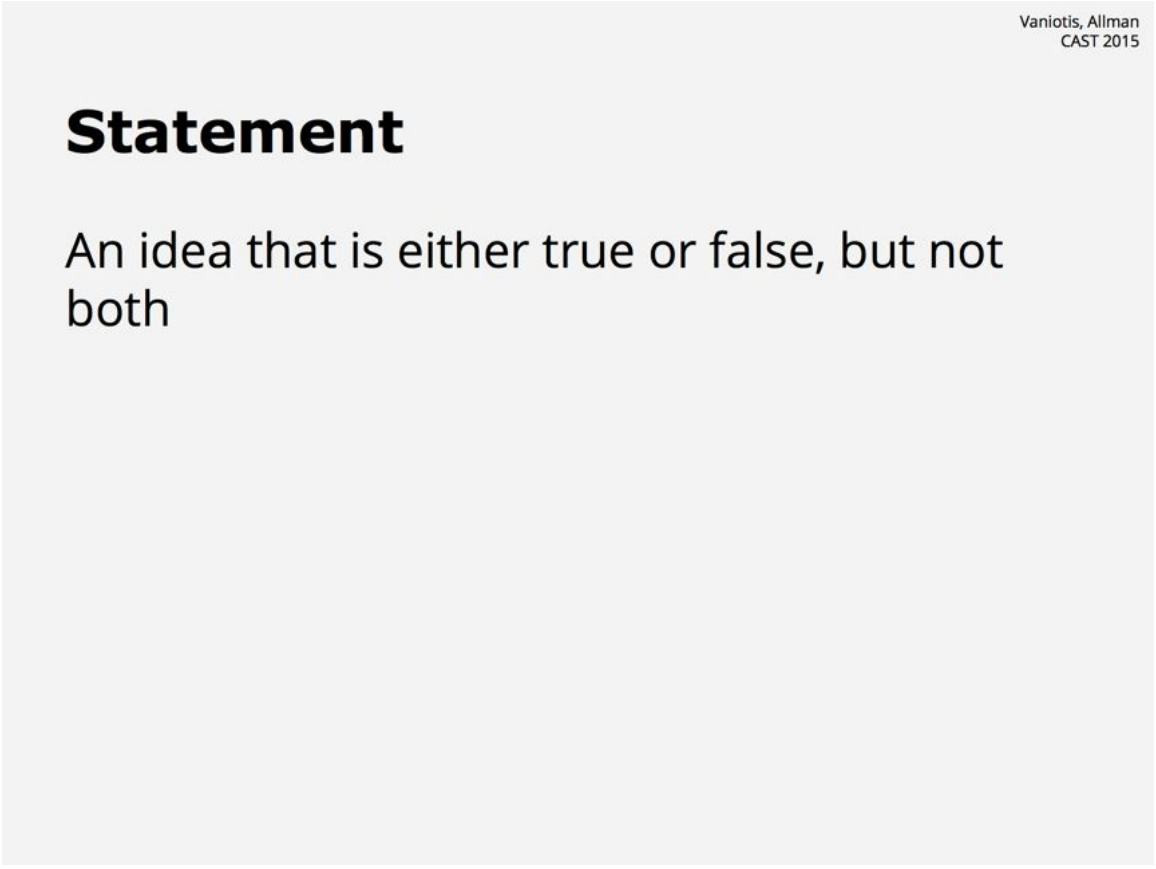


A key principle in the analysis of argument is to separate the core of an idea from the rhetorical effectiveness or personal likeability of the proponent. In order to have true dialogue, we urge using the principle of interpretational charity : interpret your dialog partners' reasoning in the way most favorable to their position, assuming that they are rational, loving human beings just like you who wish to pursue the truth of some controversy. When all parties in a conversation use this principle, respectful and fruitful dialog results.

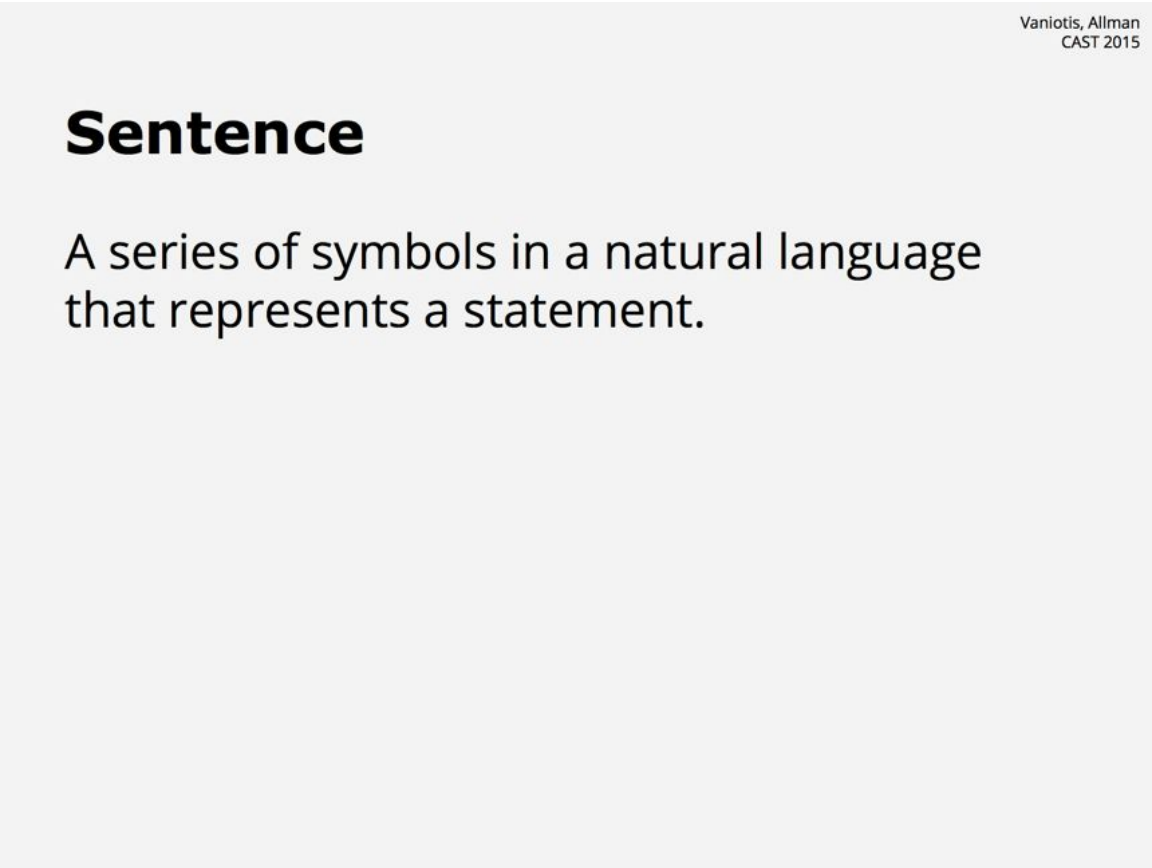
Statements and Arguments

Statements

We will now formally consider the building blocks of argument.



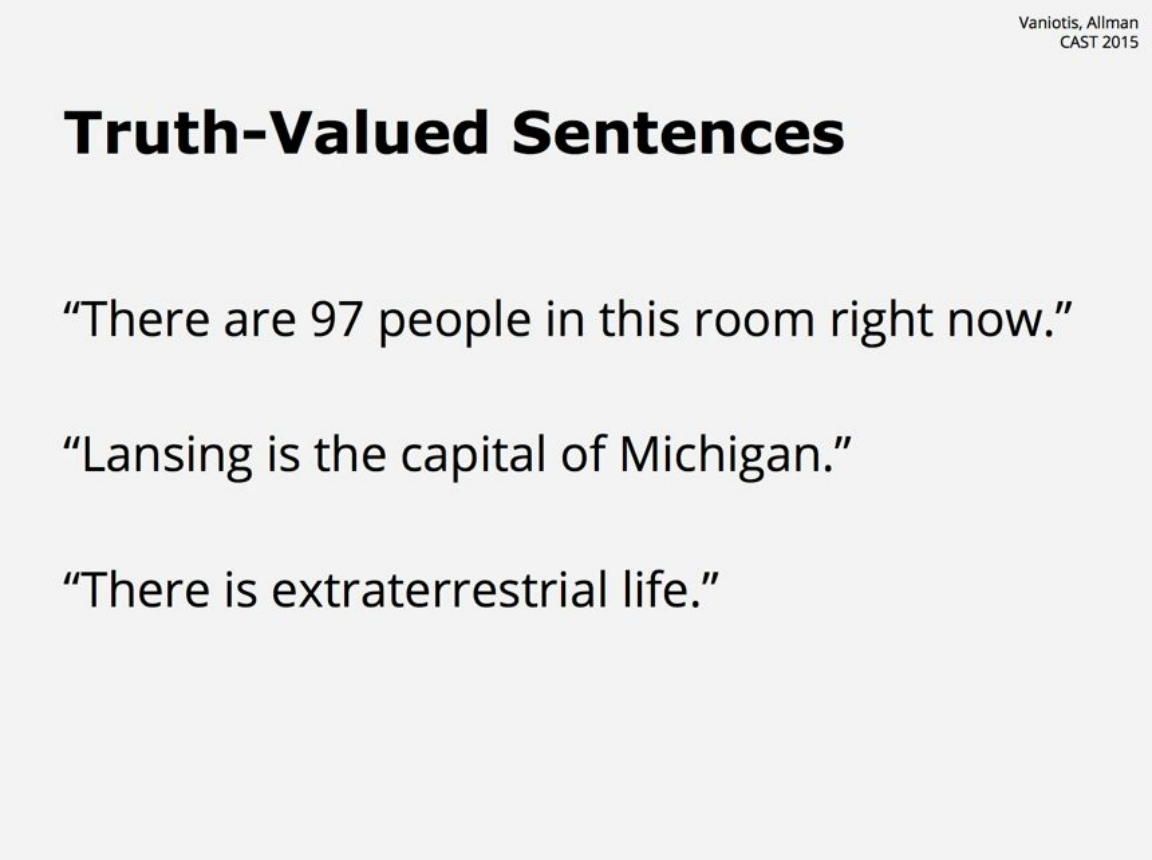
An argument is made up of statements. A statement involved in an argument must make a truth claim of an objective sort: it is either true or false regardless of what any person believes about it, knows about it, or even if it is knowable.



Sentence

A statement is something more than *just* a sentence in a natural language (because human language is full of ambiguity and nuance) but for the purpose of this talk, we will assert that sentences, specifically, truth-valued sentences, are good enough representations of statements.[1]

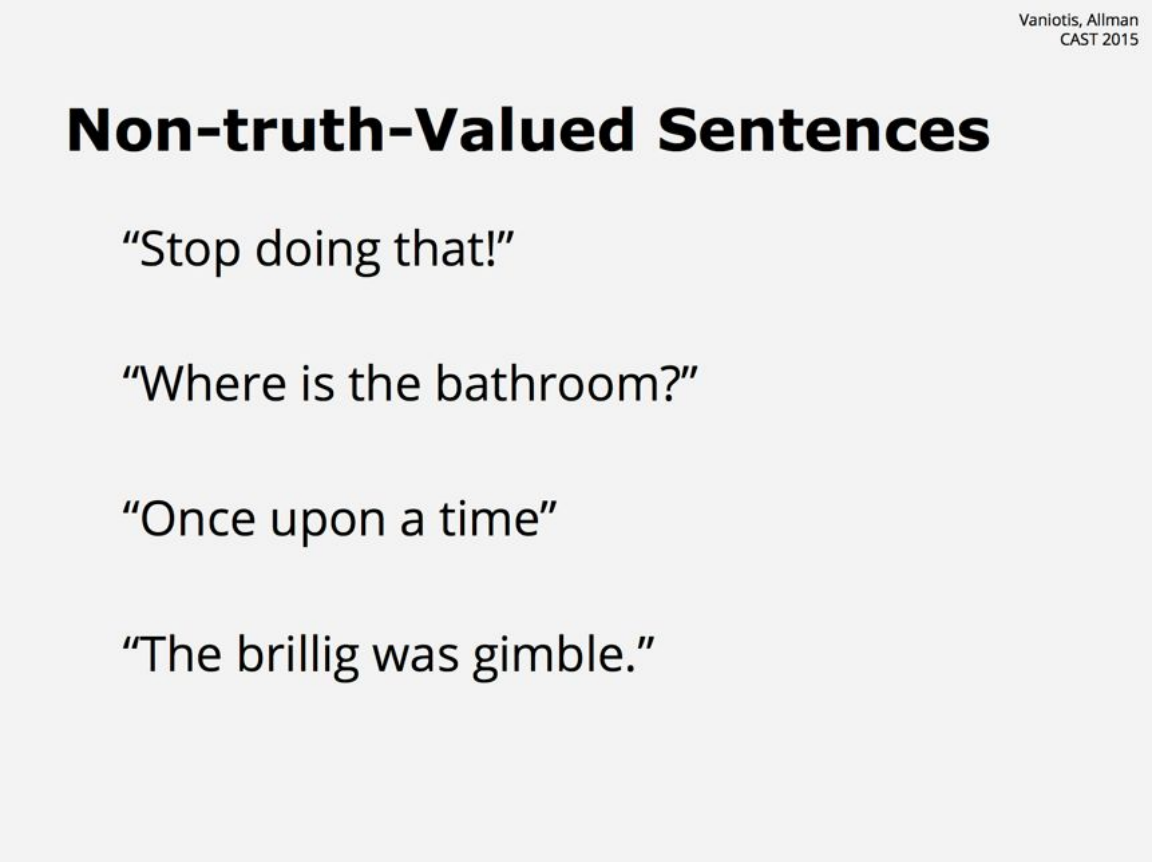
[1] The terms here defined are objects of several branches of philosophy: most notably logic (the philosophy of reason), metaphysics (the philosophy of reality), and ontology (the philosophy of existence). What we refer to as "statements" in this paper are also often called by philosophers "propositions". The Stanford Encyclopedia of Philosophy (plato.stanford.edu) article on propositions is a very good introduction to questions around the mapping between sentences, statements, and reality.



Truth-Valued Sentences

Here are some examples of truth-valued sentences.

Each of these sentences is objectively true or false regardless of what we know about them.



Non-truth-Valued Sentences

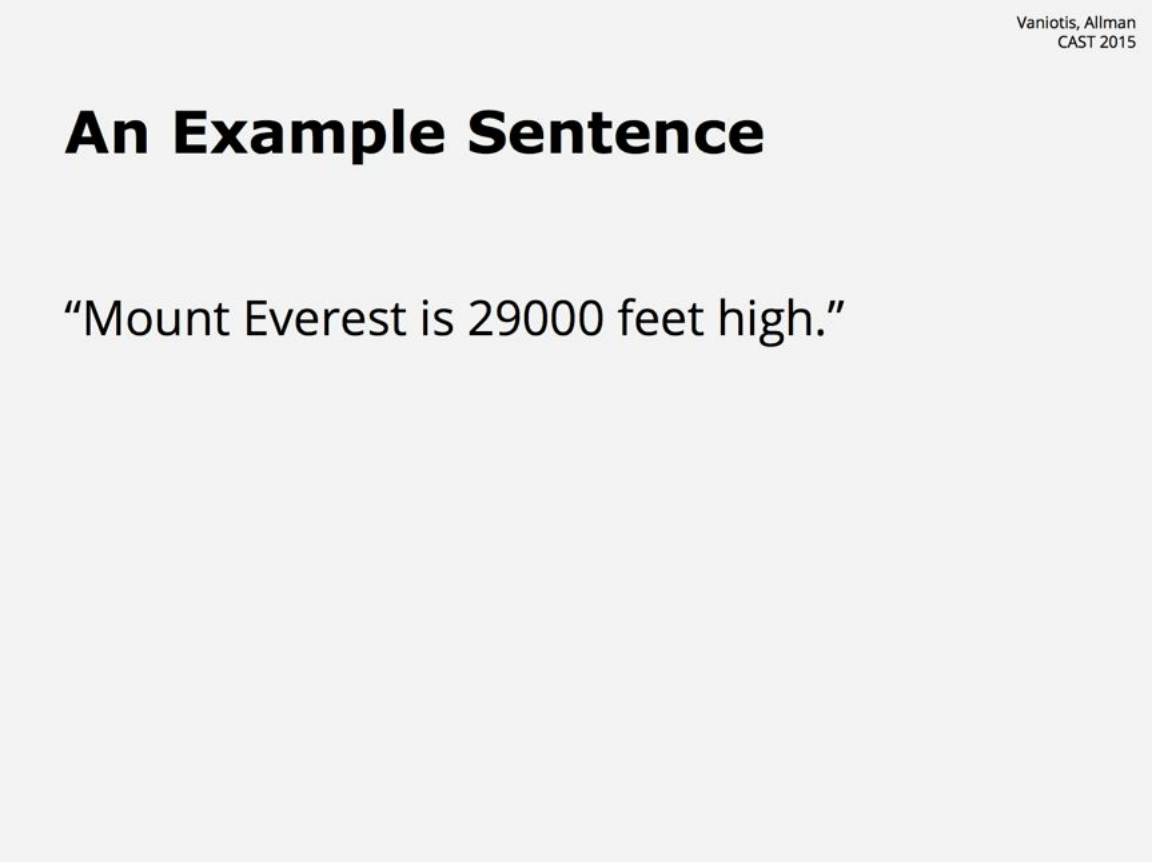
There are certainly sentences in natural languages that are not statements because they do not convey a truth claim. The sentences on the slide may be interesting, entertaining, or useful, but they are not subject to analysis as part of an argument.[2]

Assuming Context

When analyzing an argument you may find the gap between sentences and statements to be a problem. Sometimes the sentence doesn't have all the details relevant to main point of the argument, and you need to supply them to understand. Sometimes the sentence contains irrelevant details that muddy the waters.

As a simple example consider the English sentence:

[2] There are many puzzles around these sorts of sentences. They occur in informal arguments, but it it is best for the purpose of analysis to re-write such arguments with sentences that can be analyzed, using interpretational charity. The topic of sentences and how to map them in sentences is, broadly considered, within the realm of "Philosophy of Language". A good starting point is available at the Internet Encyclopedia of Philosophy at http://www.iep.utm.edu/lang-phi/).



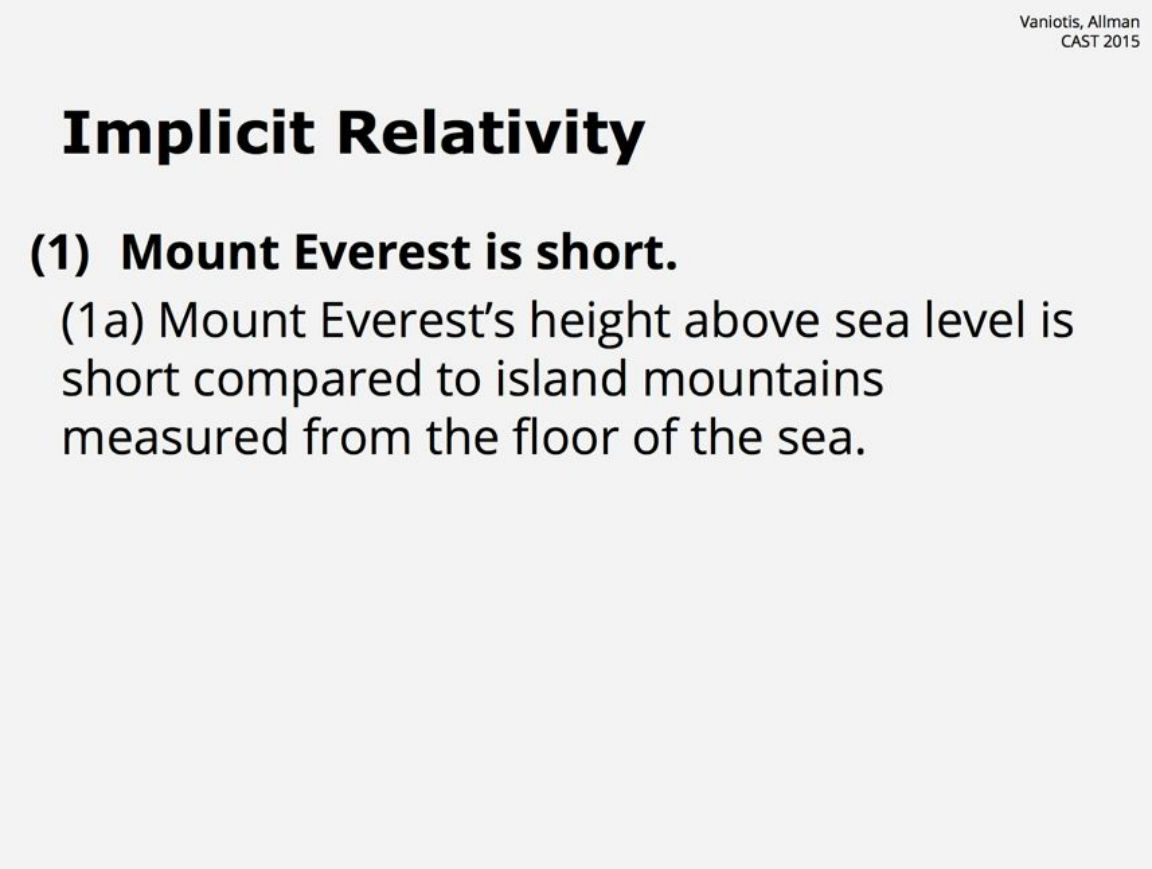
(1) Mount Everest is 29000 feet high.

If we are going to truly understand the statement (the core idea) that this sentence represents, we have to supply a lot of implied context:

- the meaning of the unit “feet”
- the technique of measuring the height of a mountain
- the date on which the measurement takes place
- and you could come up with many more.

If these contextual facts are relevant to the overall argument, they should be made explicit; but most of the time, we are communicating in a shared context. The rhetorical dodge of focusing on an irrelevant detail of context rather than the main point is a cheap trick. If we are engaged in genuine argument, we assume that parties in an argument are not trying to deceive each other and focus on working together toward the truth of the matter.

In other cases, it is quite clear that the implicit context makes a significant difference to the meaning of the statement the sentence is trying to represent. We will now present a few examples of sentences that are light in context and better sentences that would make them more effective communicators of the underlying statement.

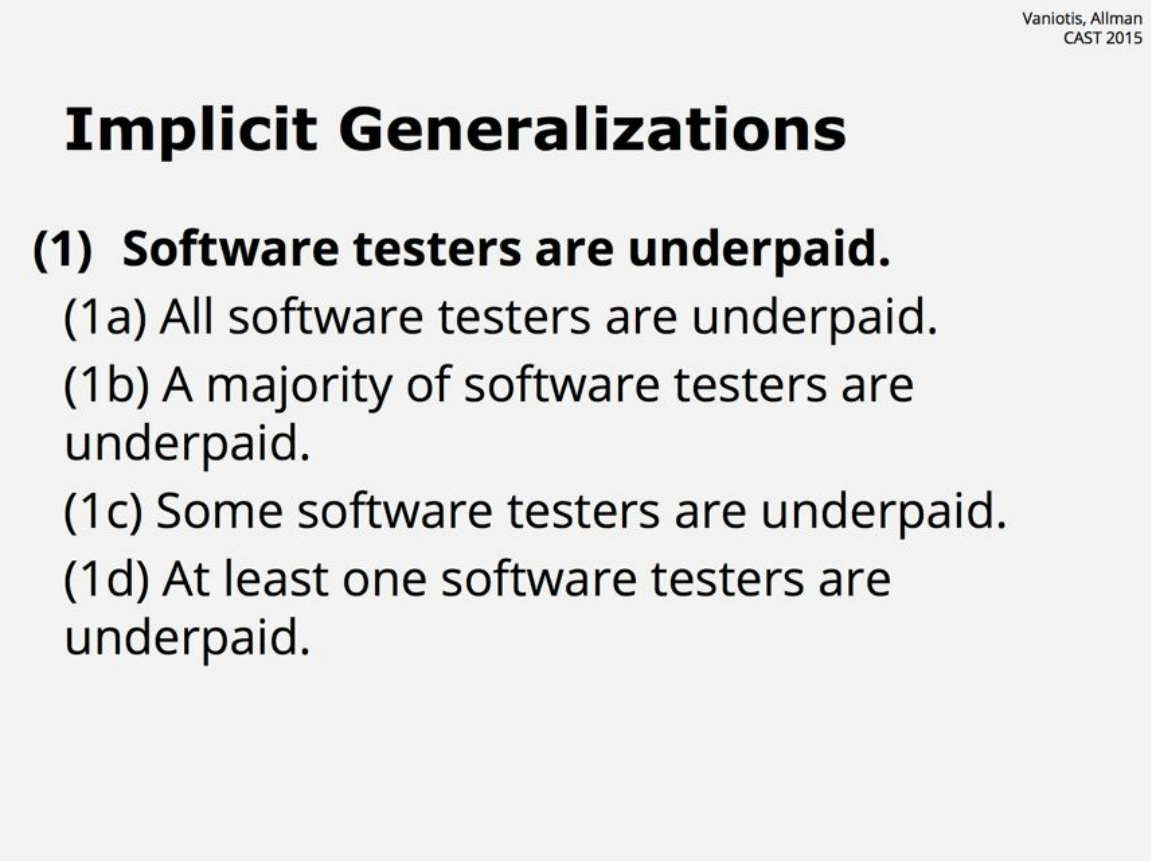


Implicit Relativity

Some sentences use relative terms without specifying what they are being compared with.

"Mount Everest is short", might seem false at first, but

"Mount Everest is short compared to some island mountains measured from the floor of the sea." with full context is plausible to believe.



Implicit Generalization

Consider an argument that relies on the sentence: “Software testers are underpaid.”

What does that sentence mean?

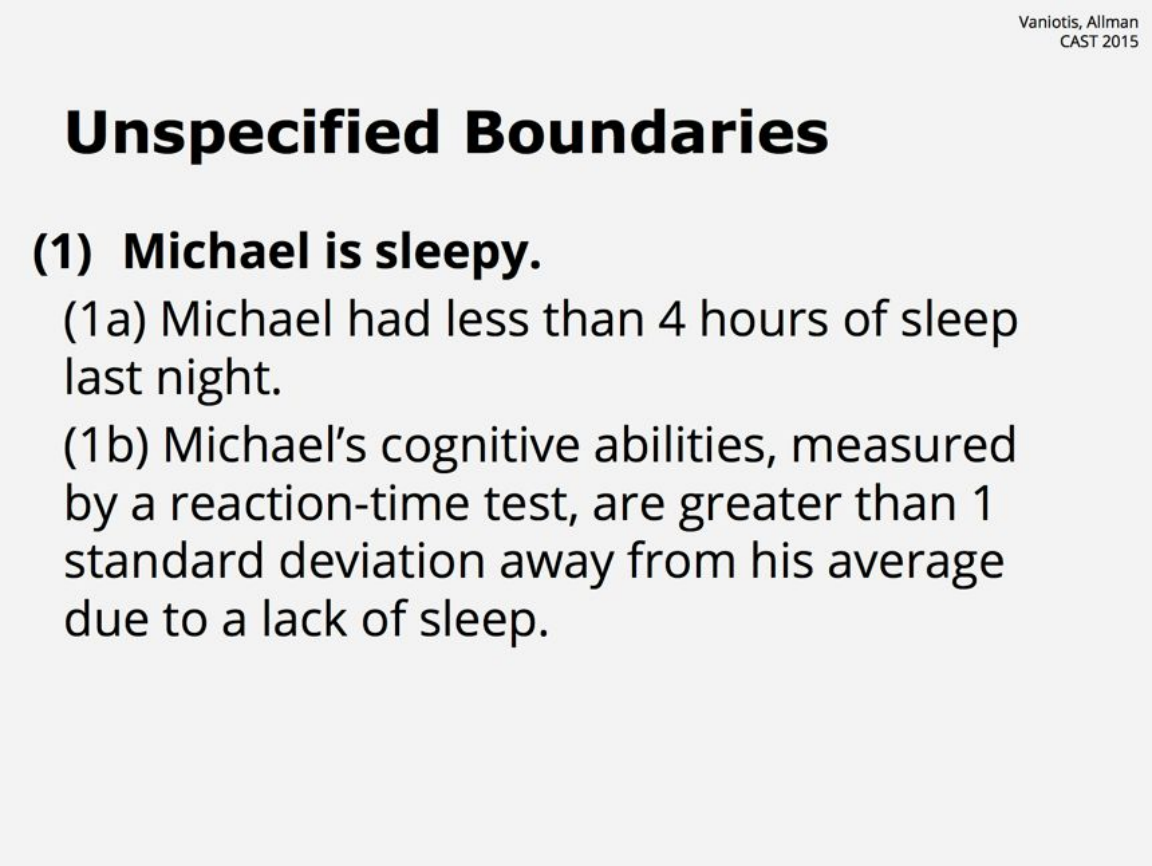
“Every single software tester in the world is underpaid.” - probably not.

“A majority of software testers are underpaid compared to the value they create.” - that seems worth debating.

“Some software testers are underpaid compared to industry average.” - a mathematical necessity.

“At least one software tester is underpaid.” - an unremarkable, but perhaps very personally relevant fact.

You can see how these interpretations of the sentence can lead to vastly different arguments.



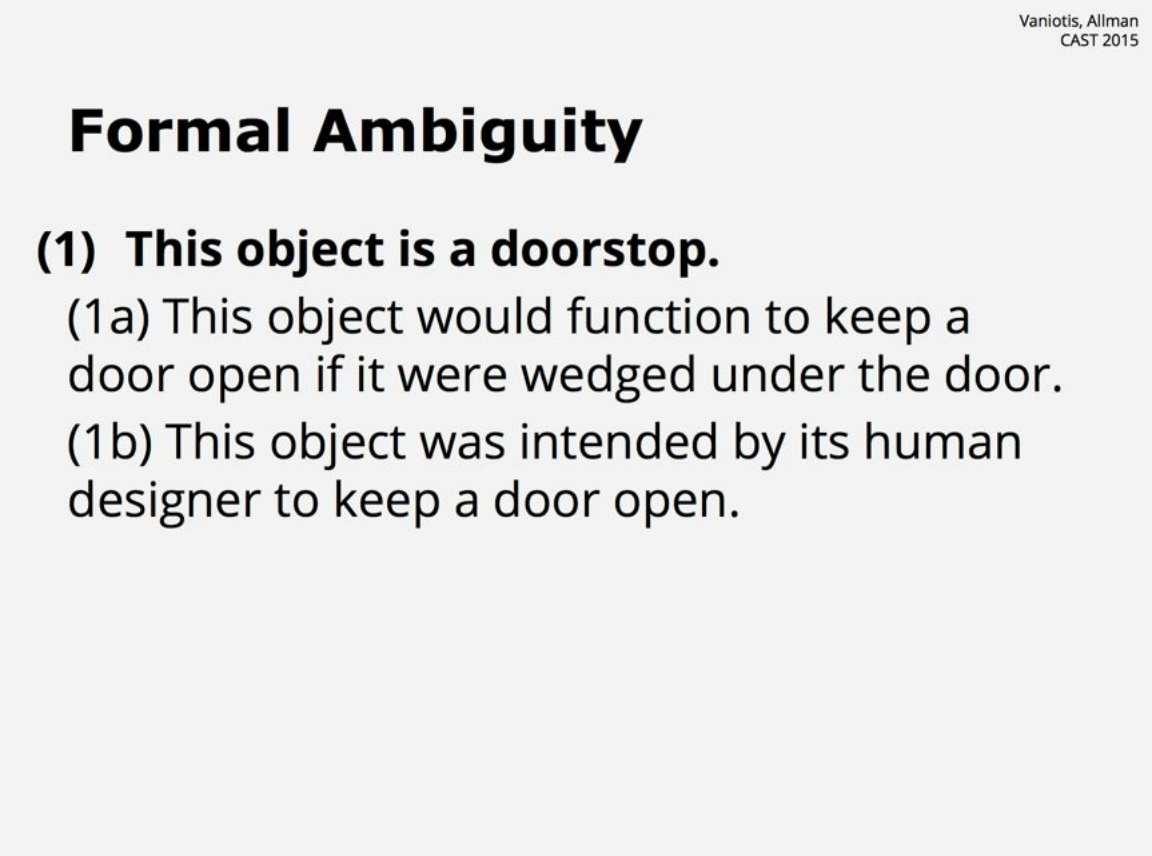
Unspecified Binary Boundaries

Some sentences use a binary distinction for something that is a continuum (or in a multi-dimensional space.)

"Michael is sleepy" can mean many things.

Maybe it is just a fact of history: "Michael had less than 4 hours of sleep last night."

or maybe something resembling scientific evidence: "Michael's cognitive abilities are measurably diminished due to a lack of sleep."

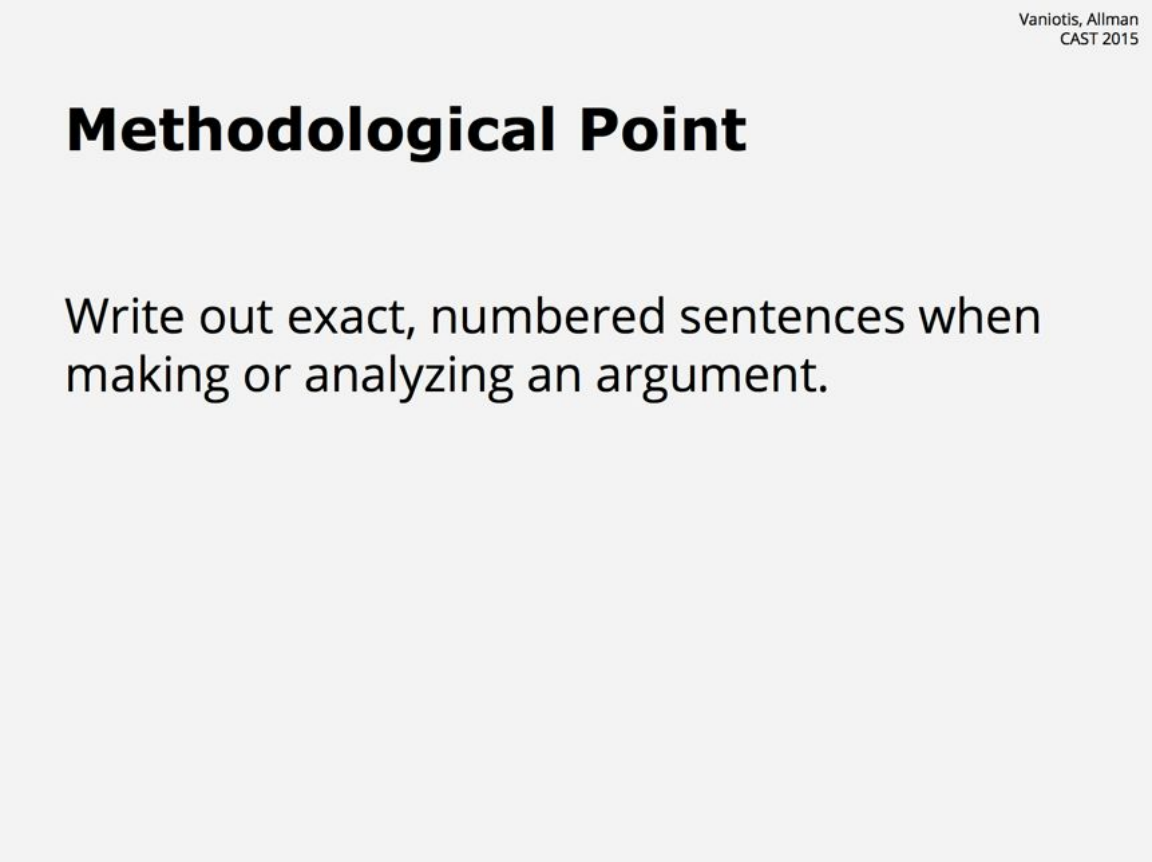


Formal Ambiguity

And finally, there are certain formal ambiguities in even very simple language like the sentence: “This object is a doorstop.”

It is better to distinguish: “This object would function to keep a door open if it were wedged under the door.” or “This object was intended by its human designer to keep a door open.”

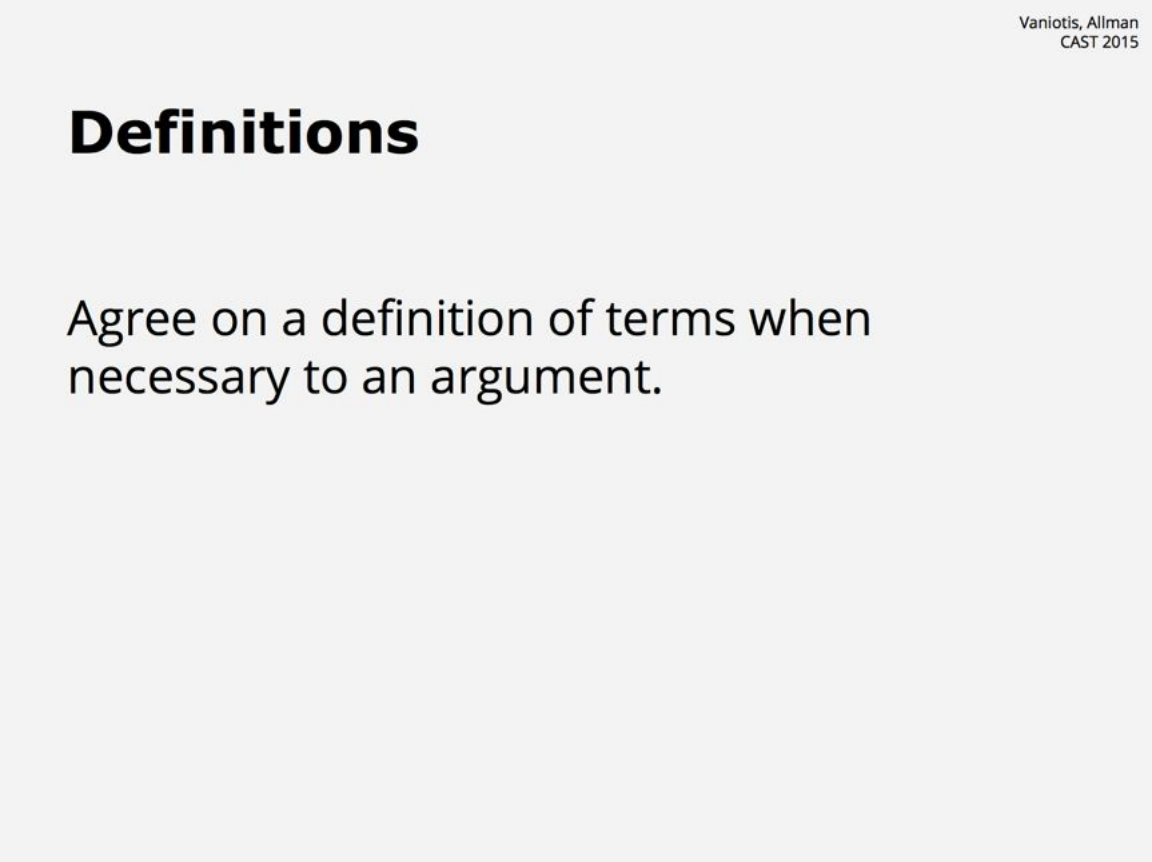
It is easy to see how language like this needs clarification in some arguments. However, these ambiguities are not intrinsic obstacles to productive argument. They just need to be raised to the surface.



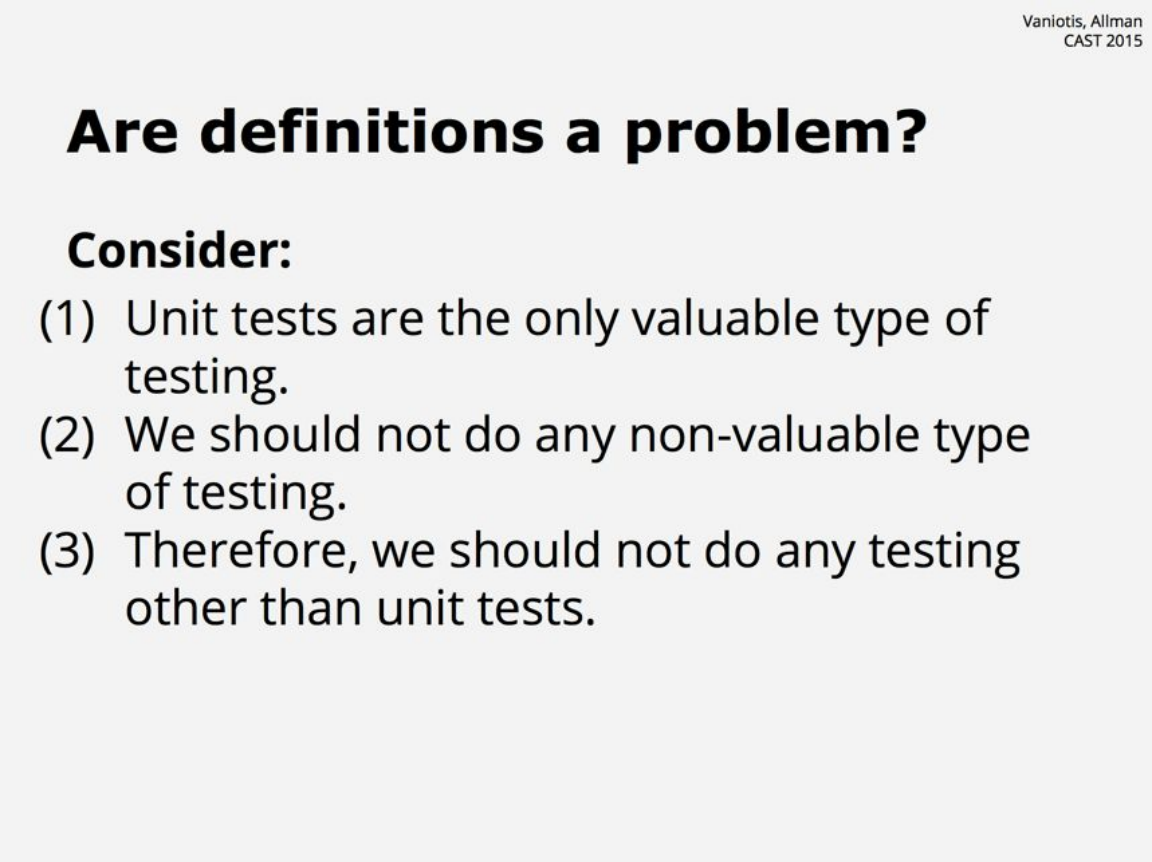
Charitable interpretation of statements

To return to our principle of charity, your analysis of an argument is most persuasive when you assume the context that makes your opponent strongest. As a matter of methodology, you should write out the version of the sentence you used when analyzing the argument so that anyone looking at your work will see how you understood the ambiguous sentence.

Definitions



Aside from the context, the words in a sentence have meaning, and it is fundamental to proceed into argument analysis with agreement about meaning. In most cases, the "ordinary dictionary definition" of words is fine, but for highly technical arguments, having a stated definition removes ambiguity.

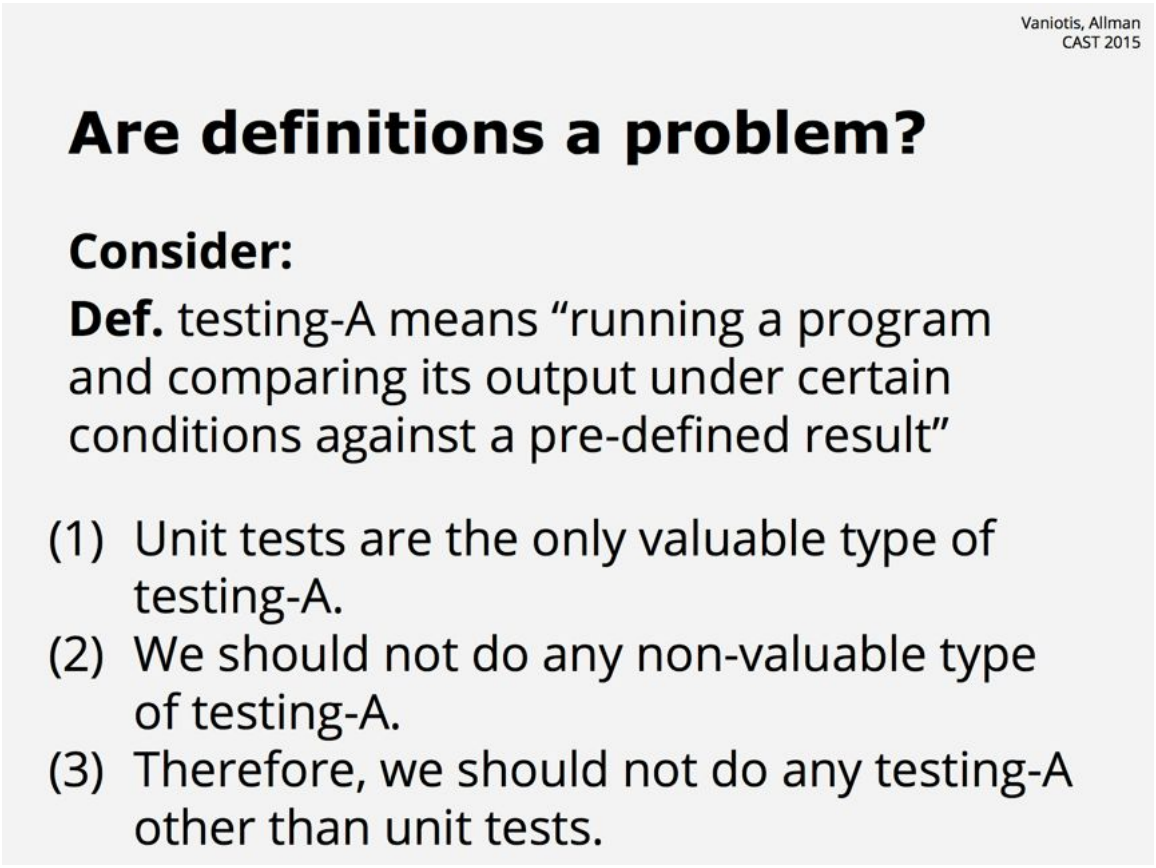


Rhetoricians love arguing about the definition of common words. Consider the following (weak) argument:

- Unit tests are the only valuable type of testing.
- We should only do valuable testing.
- Therefore, all we should do is unit tests.

It would be very tempting to get into a vehement debate about the misuse of the term “testing” to refer to unit tests. You might say it is bad for the testing profession as a whole to use the term “test” for these checks because the consequences of conflating skilled testing with unit tests are so bad! But that would be a distraction from the obvious weakness of this argument. As philosophers, we simply state:

"For the purpose of *this* argument, we define testing-A to mean 'running a program and comparing its output under certain conditions against a pre-defined result.'"



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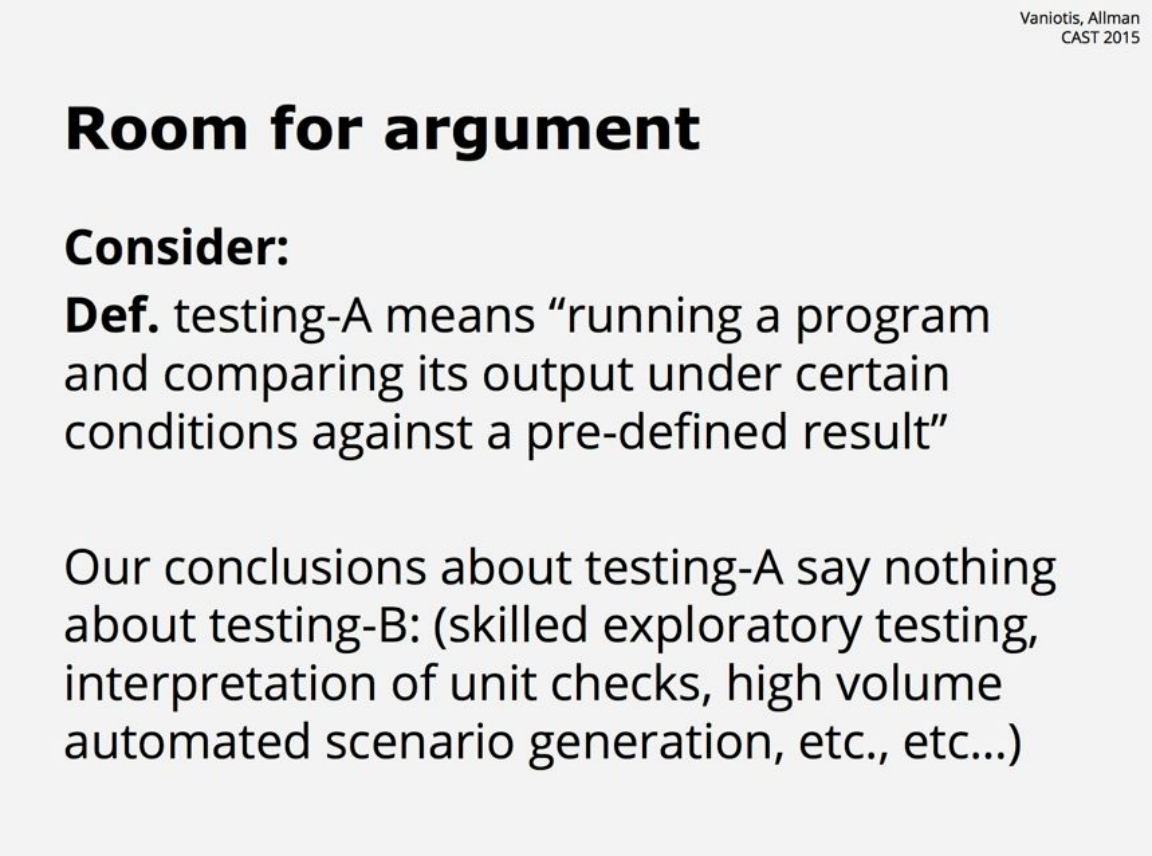
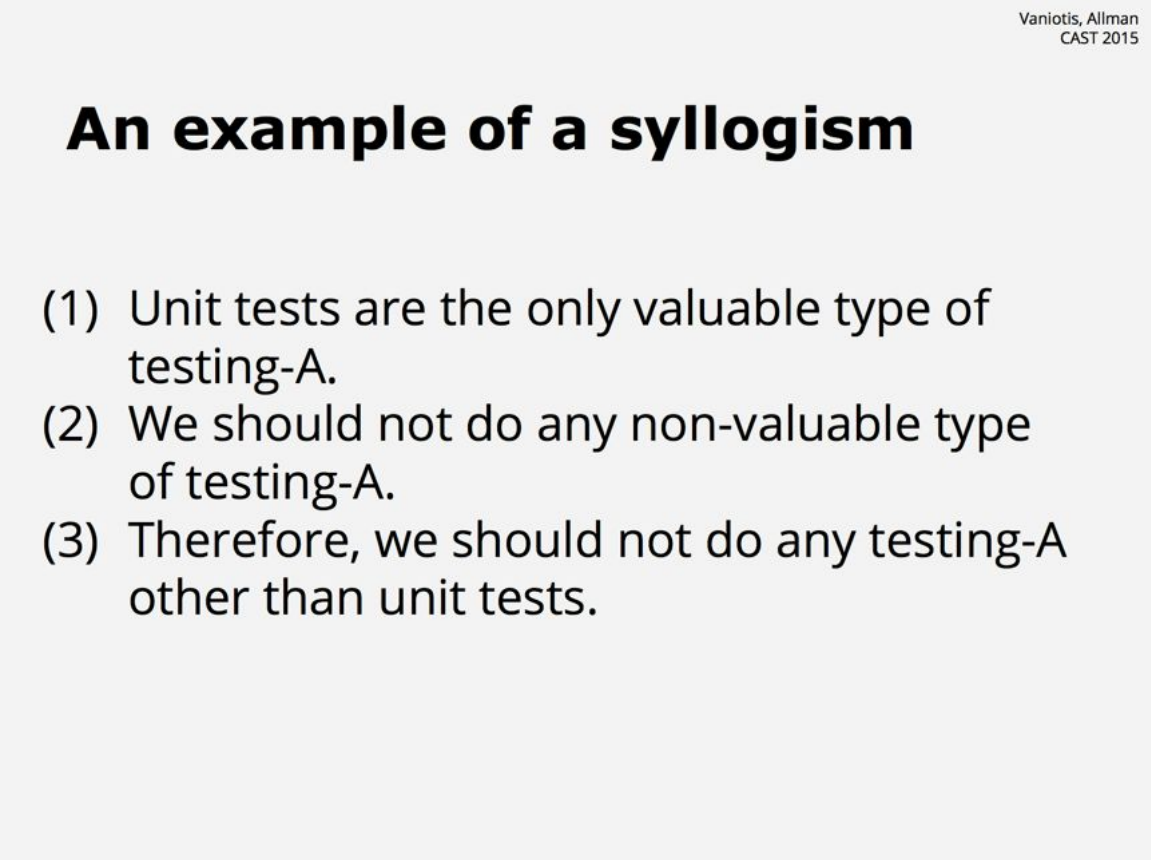
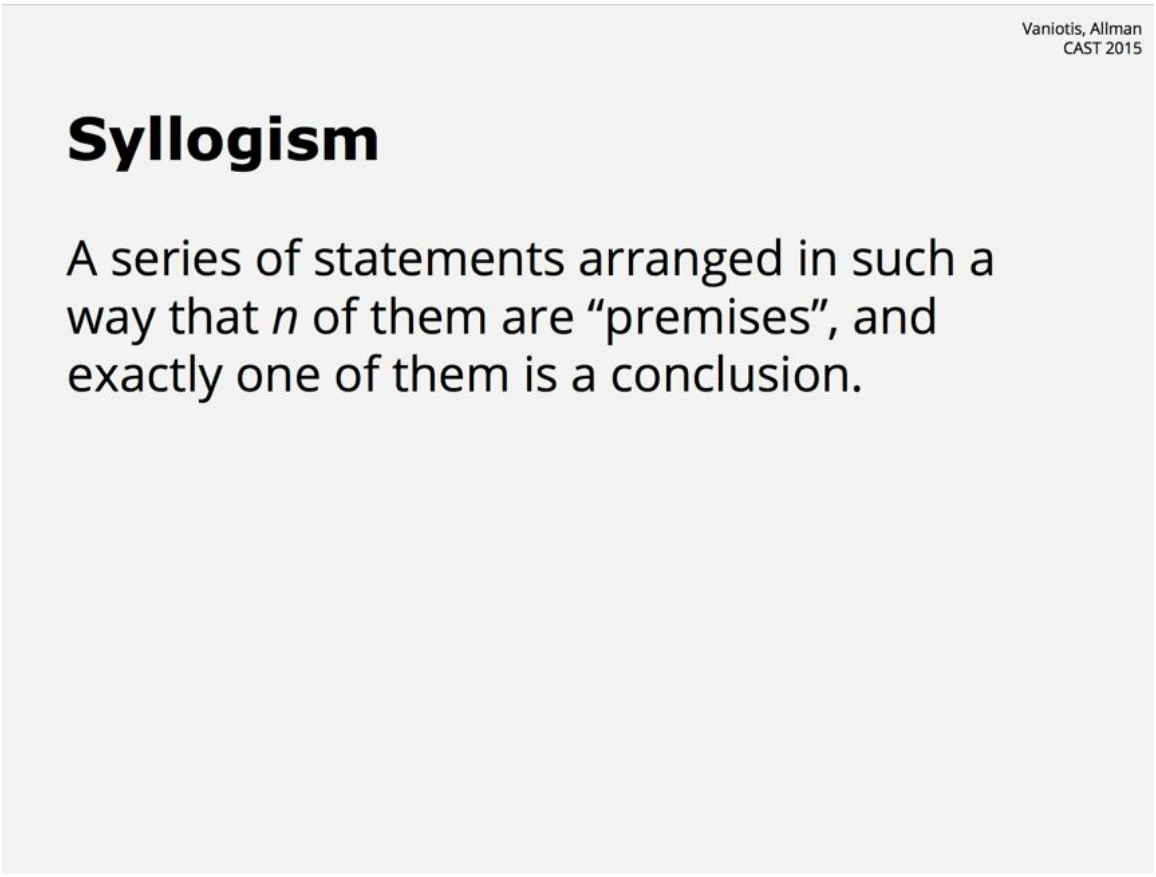


Now we can have a much more interesting discussion about unit tests as a good method of "comparing output under certain conditions against a pre-defined result" without needing to expend energy deciding whether testing-A is a good definition of testing as a whole, or if the universe needs a broader definition of testing-B.

Syllogisms

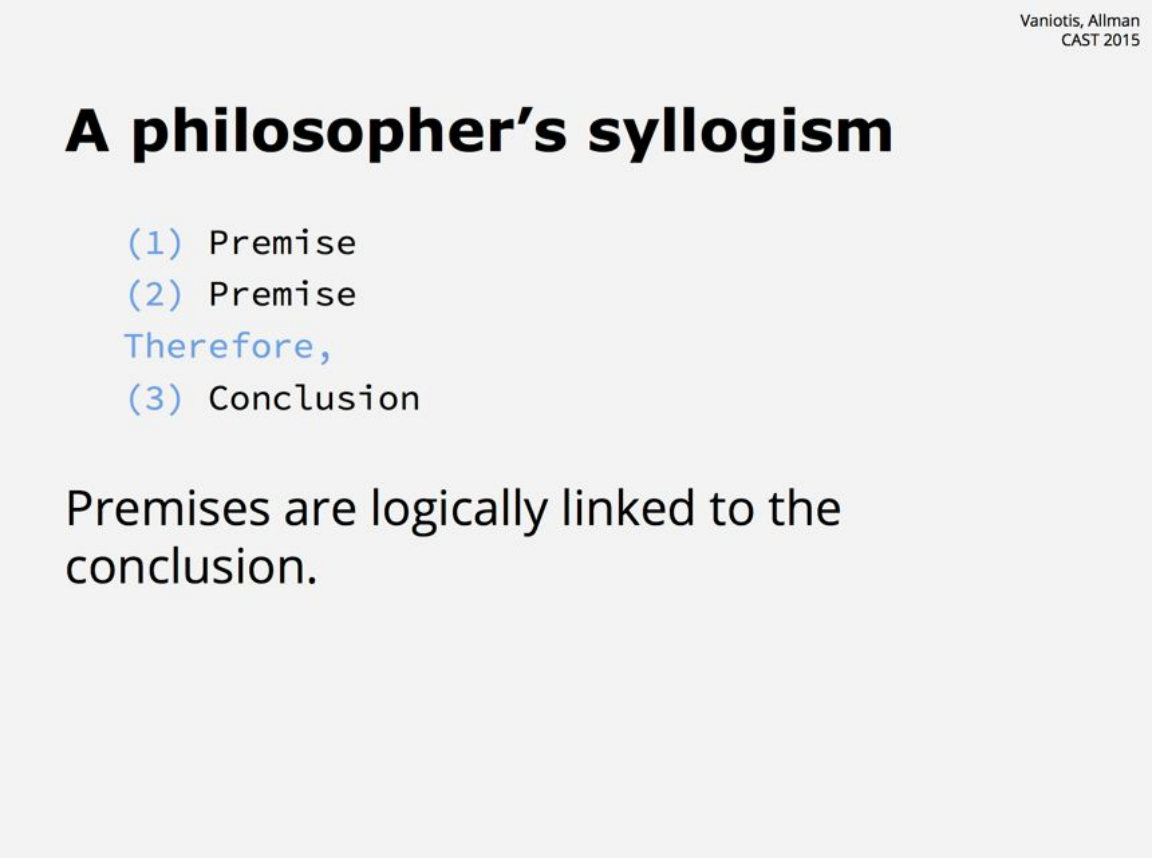
We have just examined an example of a "syllogism" (the formal philosophical term for argument).



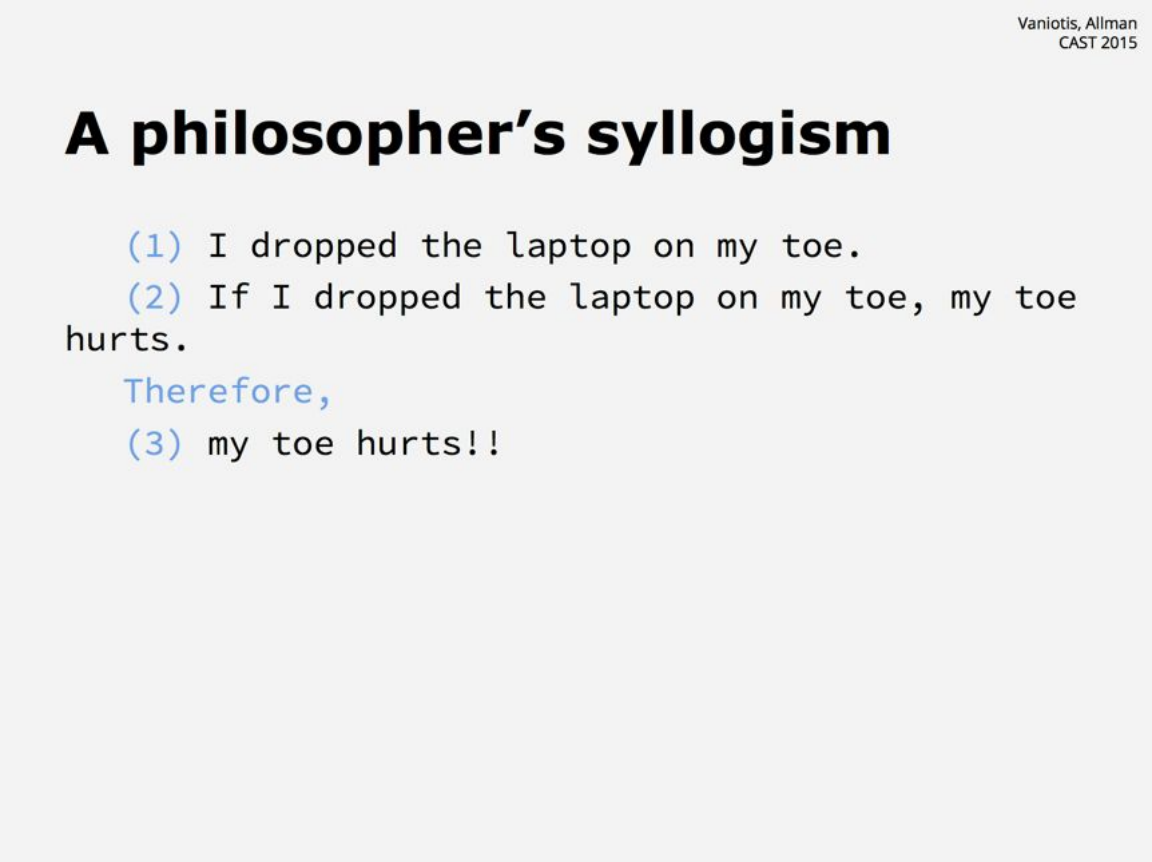


A syllogism is a series of statements arranged in such a way that N of them are "premises", and exactly one of them is a conclusion.

The premises are declarative statements relevant to the conclusion being discussed. We will speak about this in more detail later, but the idea is that in well-designed arguments, the premises are logically linked to the conclusion so that if you have good reason to believe all the premises, you will be compelled by rationality to believe the conclusion.



Throughout this paper, we will fill in these generic forms with concrete examples to confirm our intuition about the structure of various arguments.

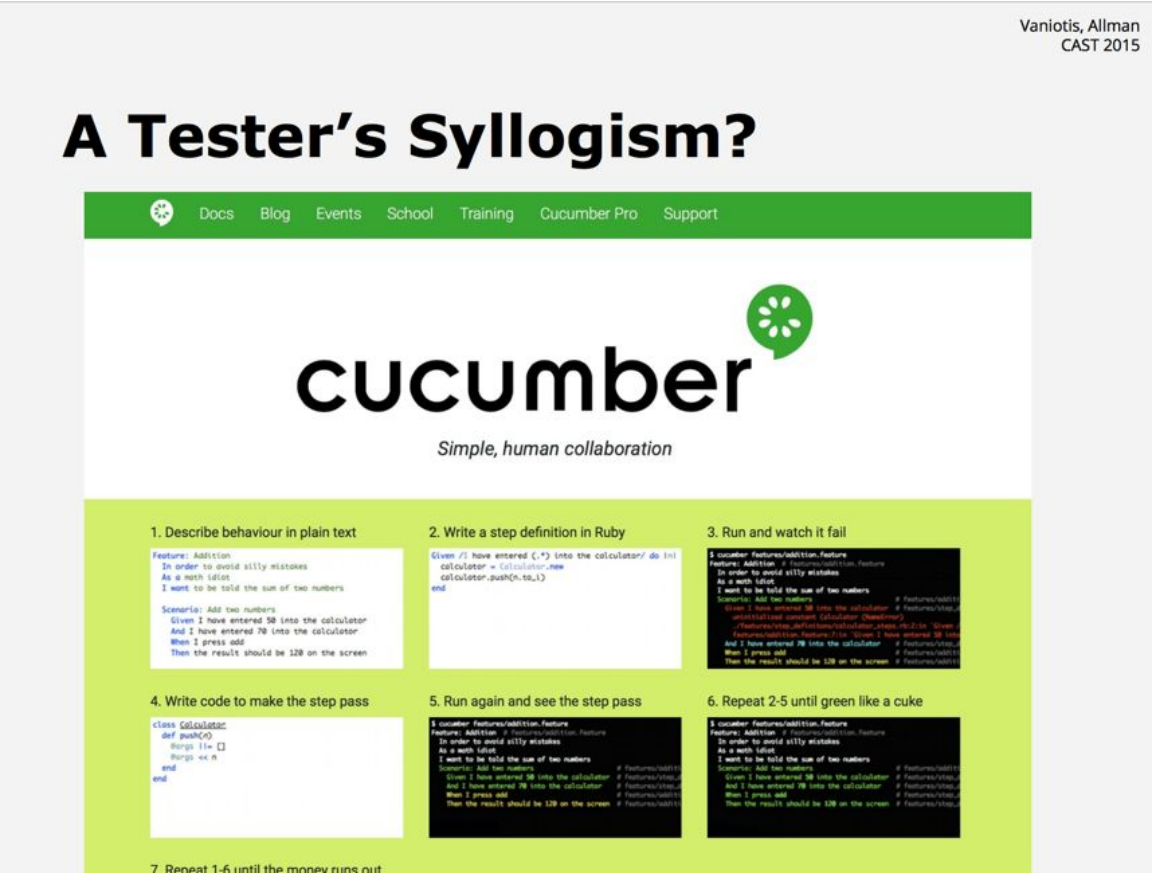


(1) Premise: I dropped the laptop on my toe.
(2) Premise: If I dropped the laptop on the toe, my toe hurts.
(3) Conclusion: My toe hurts.

Although writing out arguments in these forms seems pedantic at first, you will see how effective a tool it is, and also how it is similar to the type of activity we do in the business of software development.

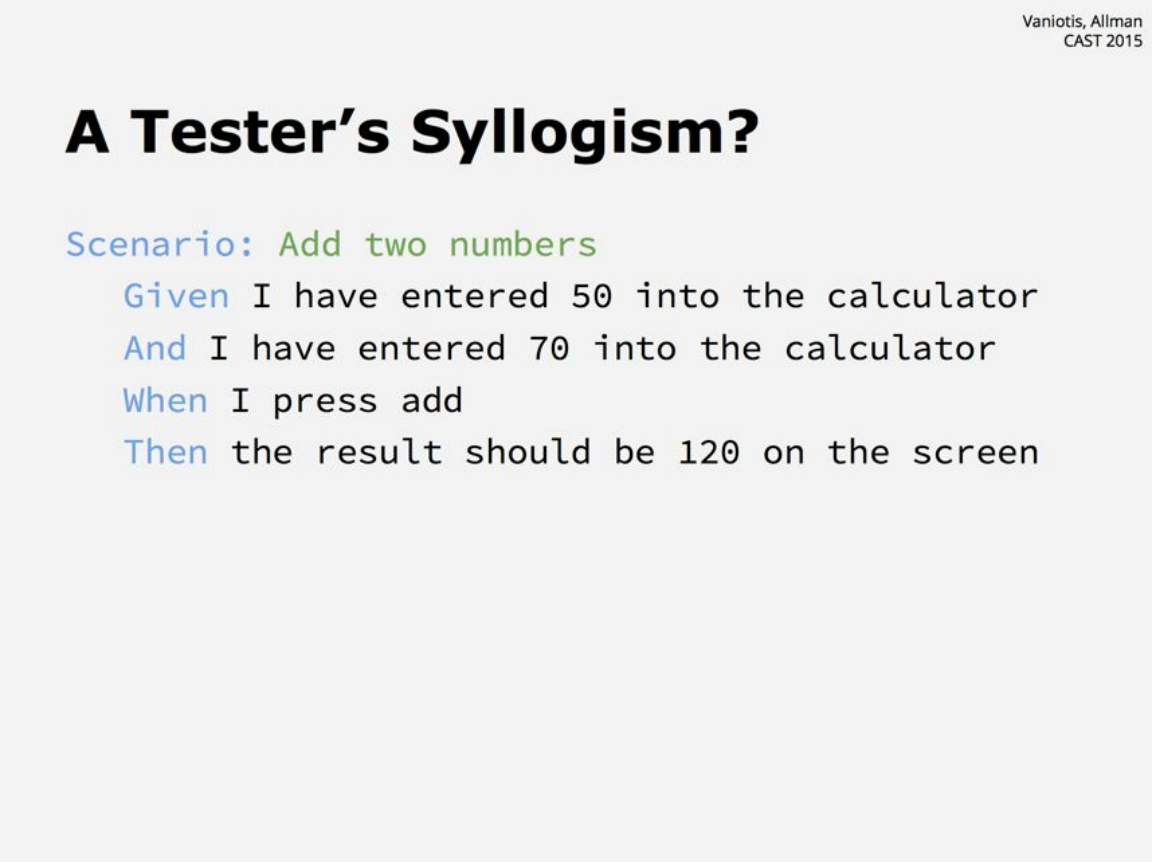
Analogy to Testing

Here is the Cucumber home page.[3]

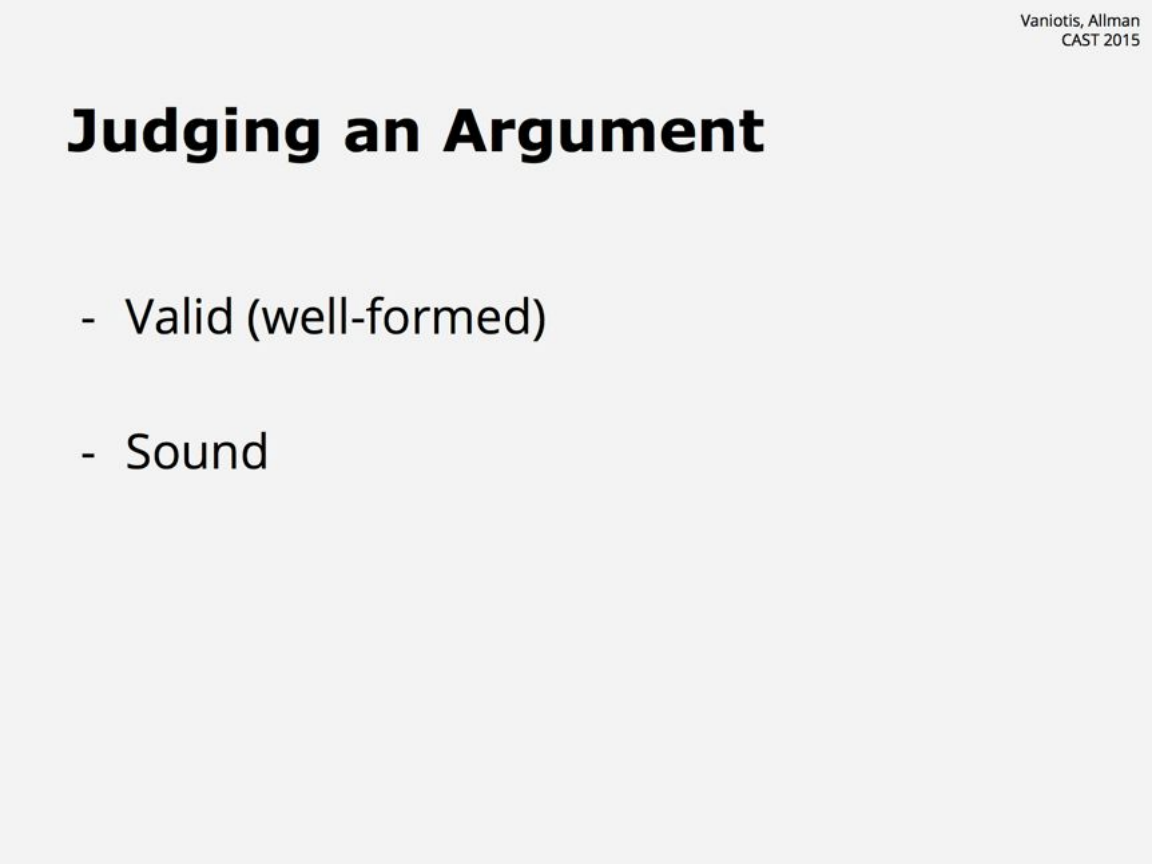


An automated script in the testing tool Cucumber can be mapped by analogy to a philosophical syllogism. Cucumber expresses a scenario in a "business-readable domain-specific language" and its format is a classic deductive argument:

[3]Screenshot of http.//cucumber.io as of August 2015.

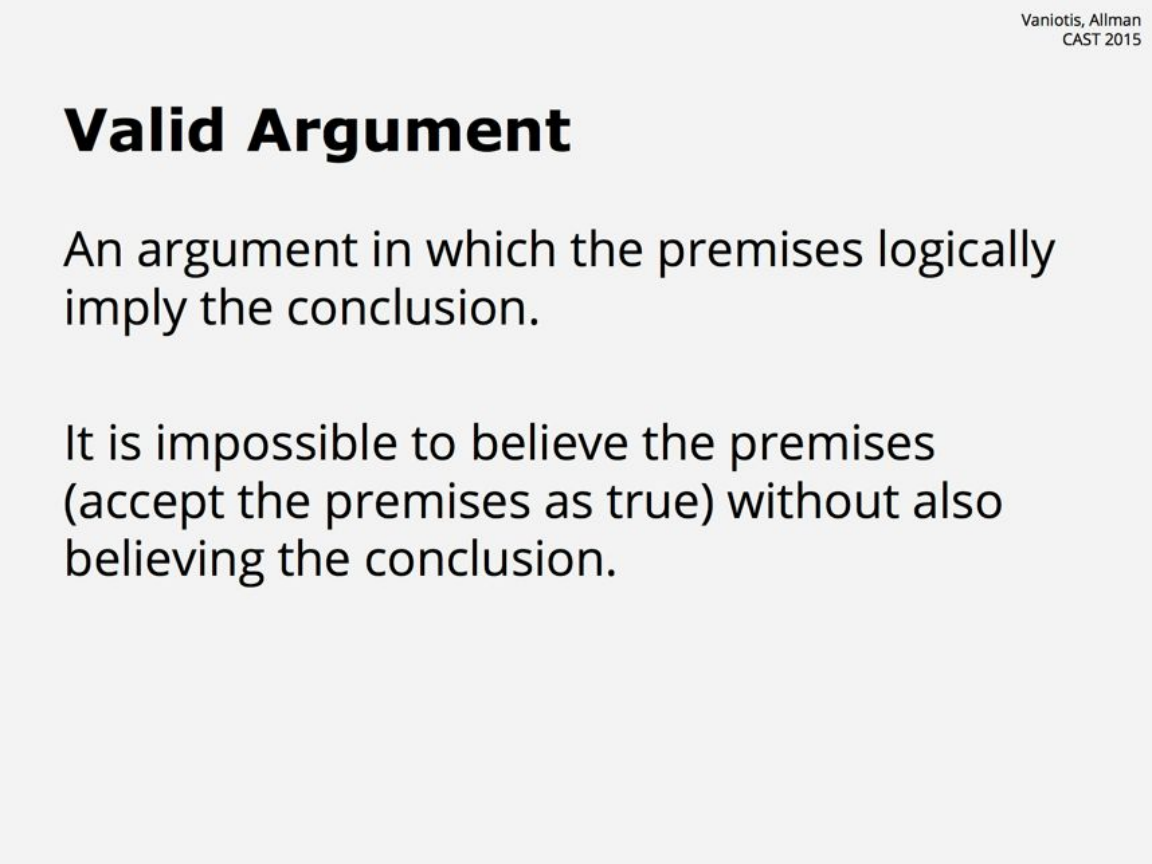


clauses "Given", "When", and "And" are premises about the software, and the conclusion is found after the "Then" clause. We will return to examples from the Cucumber tutorial throughout the course of this presentation.



Validity and Soundness

There are two absolutely essential questions we ask when encountering an argument: is it "valid"? and is it "sound"? If an argument is both valid and sound, then we are compelled by reason to accept the conclusion of the argument.



Validity (Well-Formedness)

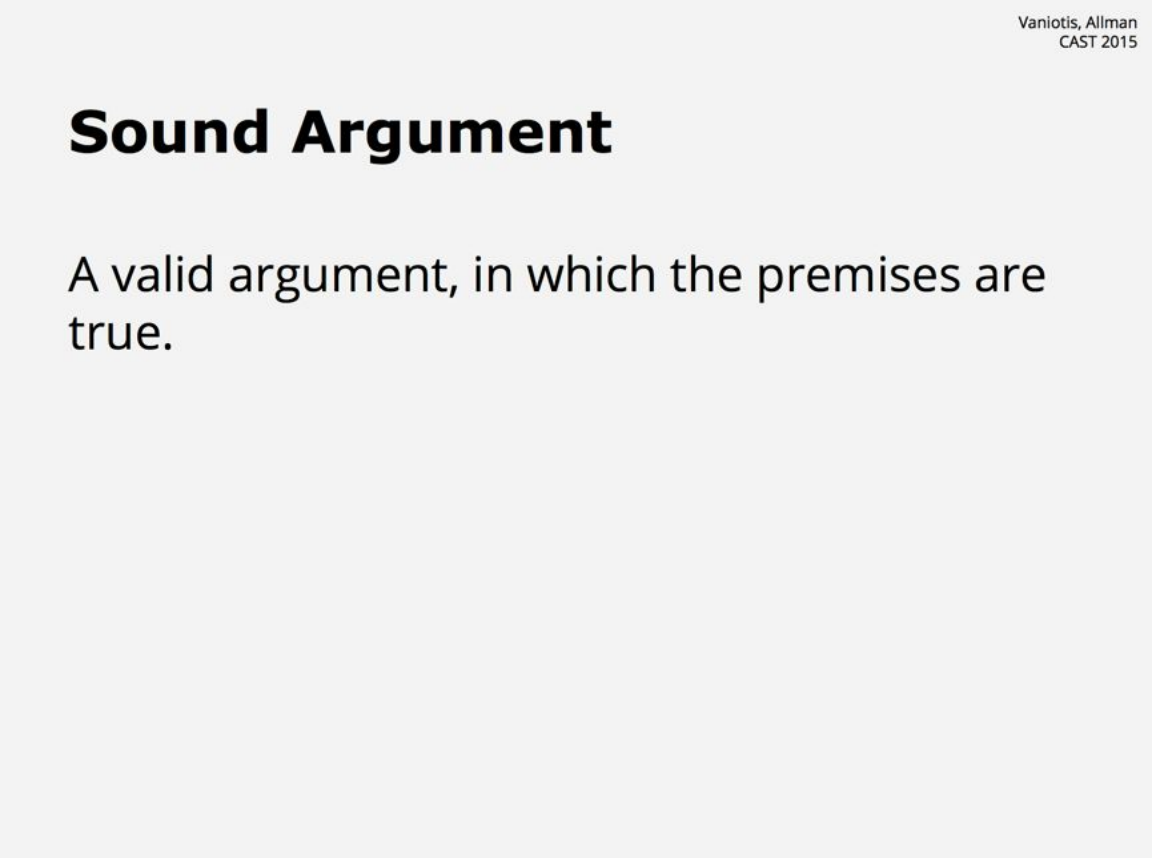
Validity is whether the argument has a correct logical form. An argument is valid when the conclusion follows logically from the premises. Or another way to put it, if all the premises are true, would the argument force you to believe the conclusion?

Determining whether an argument is valid is the very first step of evaluation. A valid argument form implies its conclusion for any premises that you can come up with. So in this first step, you suspend your skepticism and disbelief, and imagine for a moment that all the premises are true, and ask yourself, would they make you believe the conclusion?

Another term for "Valid" is "well-formed." Unfortunately due to the ambiguity of the English language, some people sense a moral overtone to the word "valid." All we mean when we talk about a "valid argument" is that it has logical force. There are plenty of valid arguments for untrue conclusions, including some that you might find personally offensive.

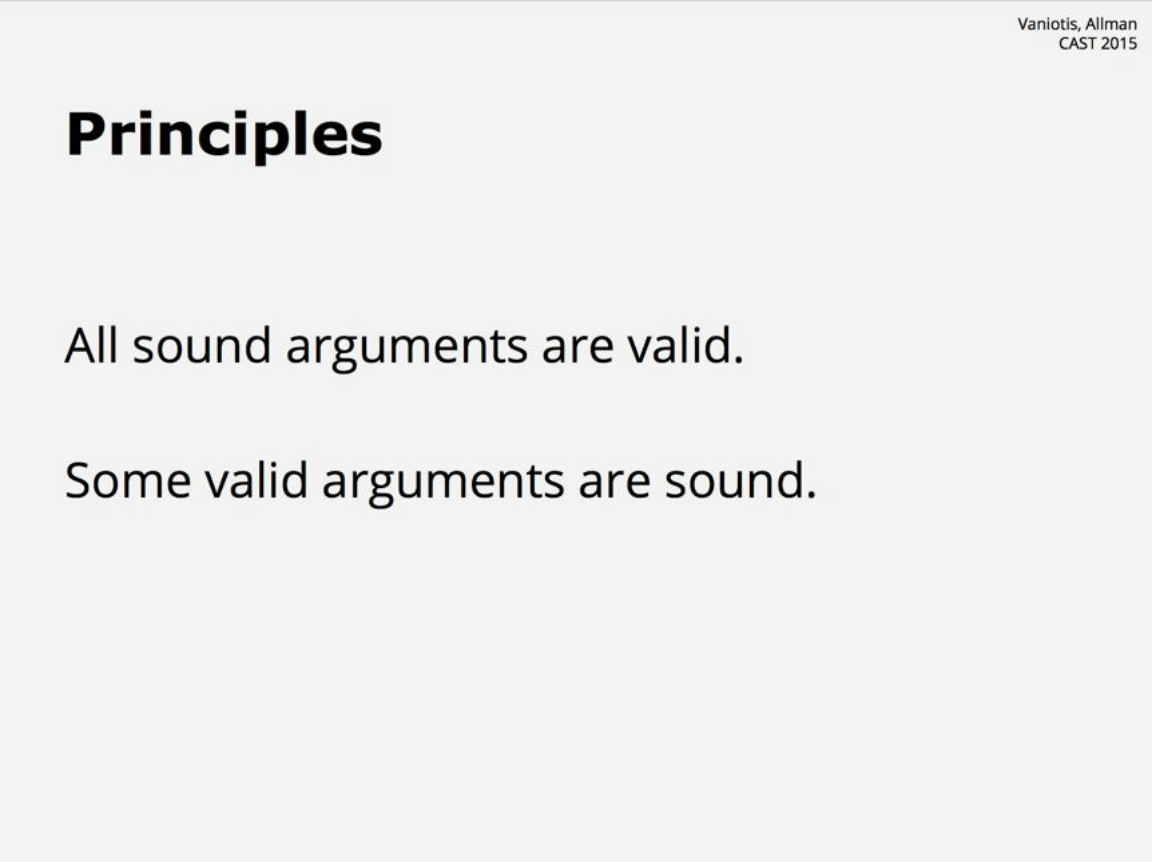
Distinguishing valid arguments from good ones is where we turn to the next key concept: soundness.

Soundness



Soundness is whether the premises in a valid argument are true. Given what evidence you have about the world and after clarifying all the context, do you believe them?

If an argument is valid and has true premises, it is sound and you must believe the conclusion.



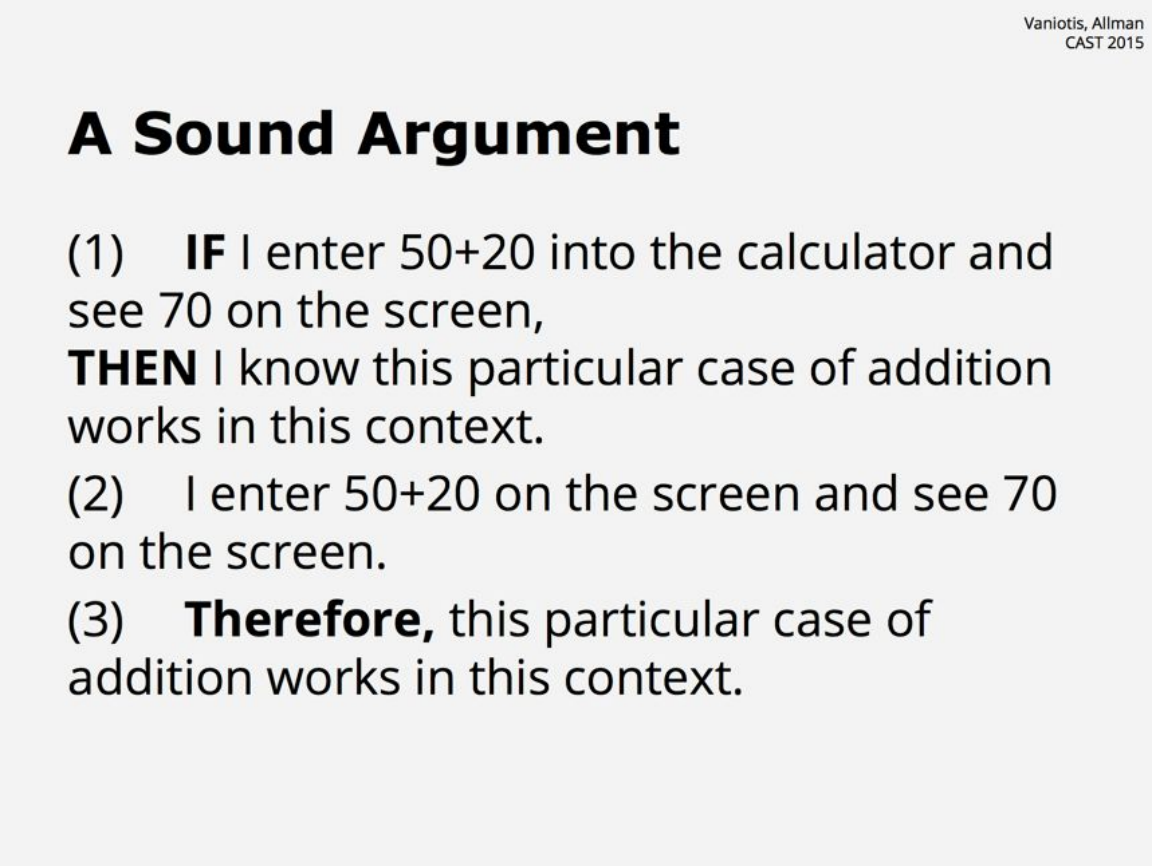
This leads us to make a few observations: every sound argument is valid, but not every valid argument is sound. Also, there are many things that are true that we don't have sound arguments for; but a sound argument never leads you to believe something false.

Most informal arguments can be rewritten in a logically valid form, and our principle of charity encourages us to do this. When analyzing an argument from a rhetorical source such as a speech, editorial, blog post, or even an academic essay, the points of interesting analysis often come from the evidence given for the premises.

Examples from software

We will use some simple examples from software testing to explore these essential concepts of validity and soundness in more detail. We will adapt the Given/When/Then Cucumber syntax into the style of philosophical arguments.

The base case here is a sound argument which we will show just for illustration.

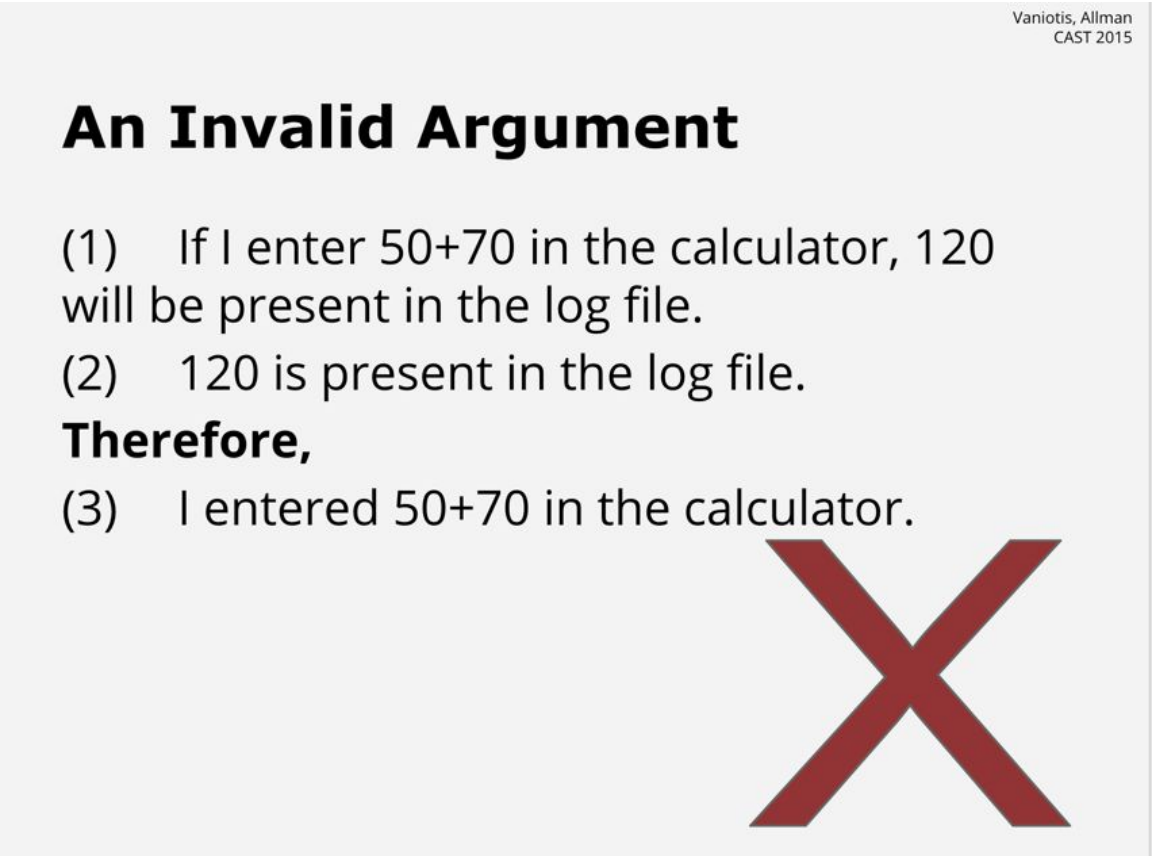


First we look at the form. It's basically "If A, then B. A is true. Therefore B." Elementary logic[4] demonstrates any argument of this form is valid.

So we turn to the question of soundness and evaluate the premises. I think even the most skeptical among us would say it's a reasonable thing to believe that if I enter 50+20 and see 70, that particular case "works".

And we run the test and observe the result - so we now have evidence for number 2. Since all the premises are true, and we have a valid argument form, this is a sound argument, and we are compelled by reason to believe the conclusion.

[4] The particular form of argument there is known as *modus ponens,* an example of a "rule of inference". The Wikipedia entry on Rule of Inference is a good initial treatment, for more detail, consult plato.stanford.edu on Classical Logic.



Invalid argument with true premises (unsound)

Here is an example of an argument that is unsound even though it has two true premises.

Imagine the simple calculator program also has a log file.

(1) The requirements tell me that if my test enters 50+70 in the calculator, 120 will be present in the log file.

(2) I inspect the log file and find 120 there.

(3) Therefore, I conclude that my test entered 50+70 in the calculator.

Is that right?

It happens that the program doesn't have a bug - it indeed adds 120 to the log file when I enter 50+70 in the calculator, so premise (1) is true.

Also, I have examined the log file and determined that (2) is true, the log file does contain 120.

However, those facts alone are not enough for me to accept conclusion (3). It might be that 120 was left in the log file from the last time I ran the test, or because I entered 2*60 in the calculator. This is a clear case of true premises leading to a false conclusion because of invalid reasoning.

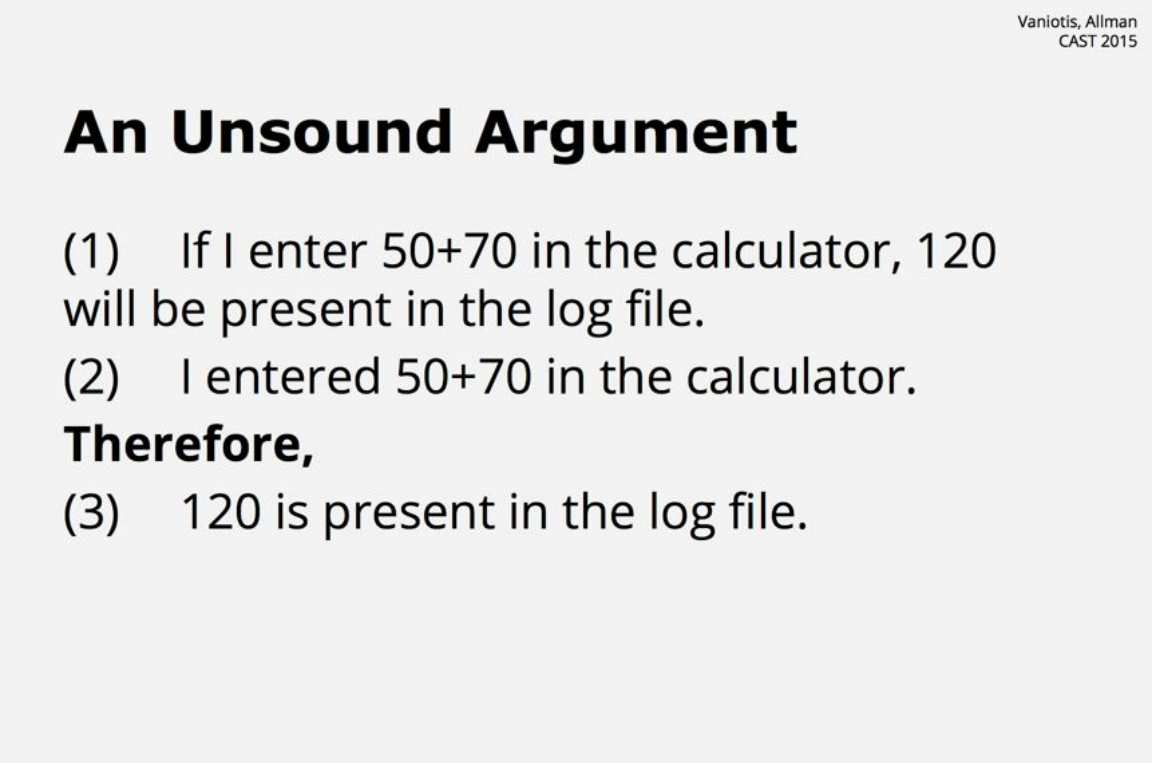
Valid argument with false premises (unsound)

Of course, a valid argument is not enough to lead us to a true conclusion. Consider this example:

(1) Because we know how addition is supposed to work, we believe if I enter 50+70, I will see 120 in the log file.
(2) I enter 50+70 in the calculator.
(3) Therefore, 120 is present in the log file.

This argument is valid – the premises logically entail the conclusion. But there are two ways it can fail to be sound. The first is if premise (2) is false – I may think I entered 50+70 but there's something wrong with my script and it doesn't enter those values. The second, and generally more interesting case for the tester is if premise (1) is false and the feature that I am testing is not implemented properly.

This is a common rubric for testers: construct a valid argument that would be sound if there is no bug, and then find evidence that the necessary premises are not true. Careful testers know to use multiple types of evidence to validate the truth of premises in an argument.



Common Fallacies

Developers note “code smells” in patterns of code that warn them of a potentially buggy feature. Philosophers develop a similar intuition for bad argumentation and group them into patterns called “fallacies.”

Fallacies are collections of statements that resemble an argument but are invalid. We can generally consider fallacies to fall into two types: **logical (or formal) fallacies**, in which the argument has a flaw which renders it invalid, and **rhetorical fallacies**, which are employed to persuade philosophically unsophisticated or apathetic audiences. As lovers of wisdom, we should practice the skills necessary to argue persuasively without resorting to rhetorical manipulation and inoculate ourselves against being swayed by them.

Rhetorical Fallacies

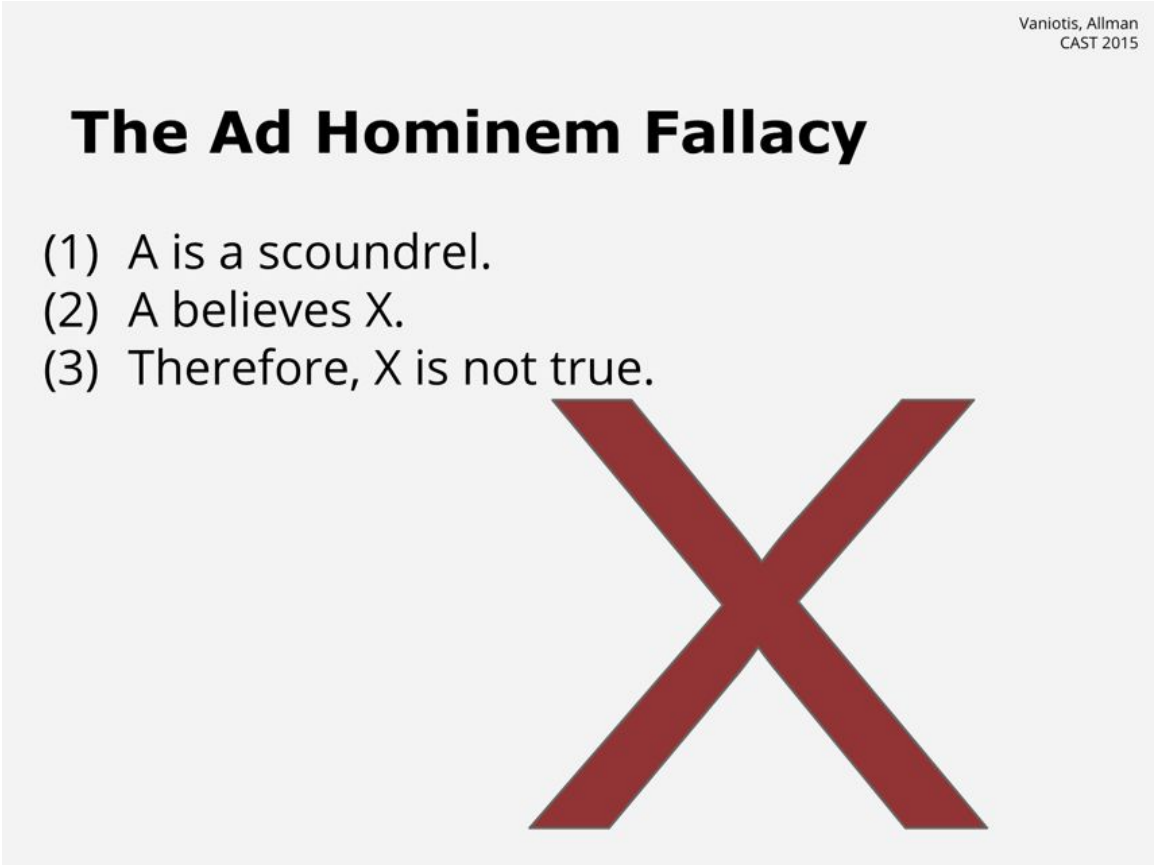
CAST 2015. Vaniotis and Allman. “Reason and Argument for Testers”

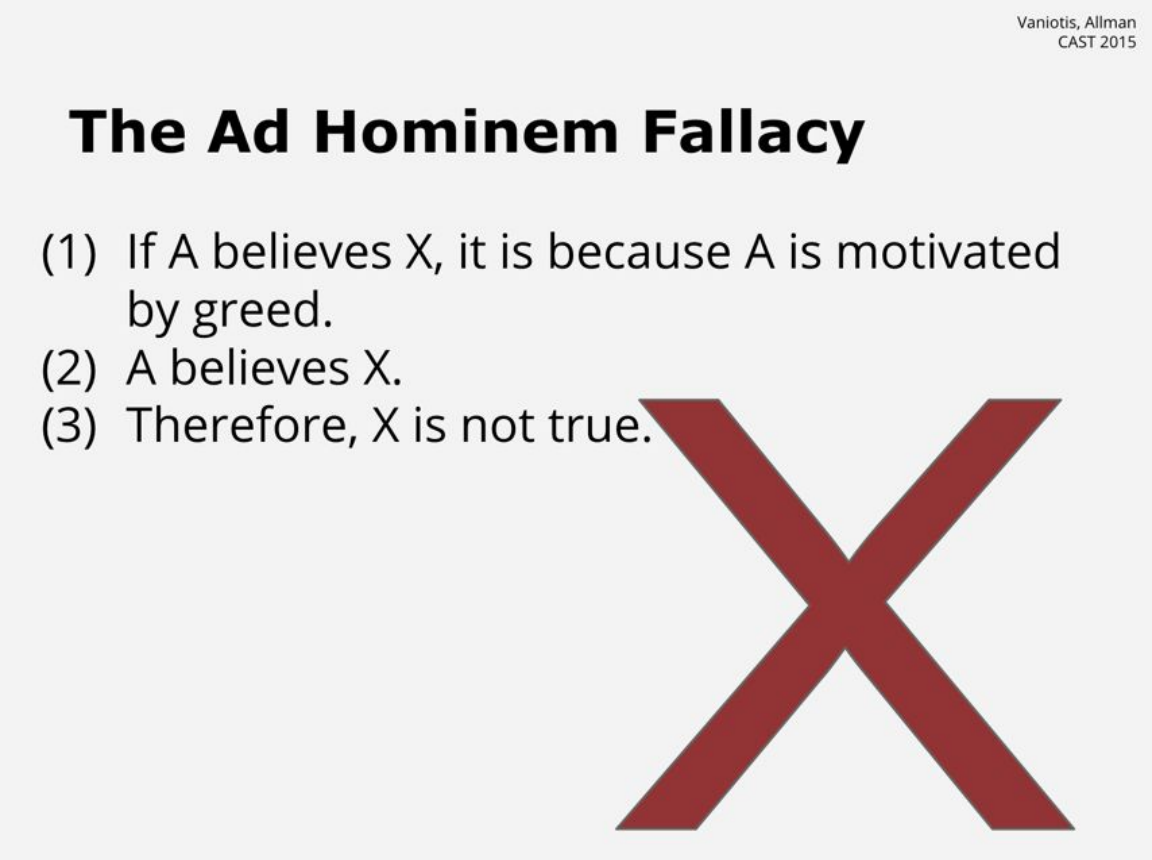
Ad Hominem Fallacy

An *ad hominem* (Latin for "against the man", or "against the person") makes the mistake that because there are bad qualities of a particular person (or group of people), something else that person believes is false or untrustworthy. This fallacy is often used in political rhetoric. In its bald-faced form, it is obviously invalid:

1. A certain person is a scoundrel.
2. and that person believes a thing X.
3. Therefore X is not true.

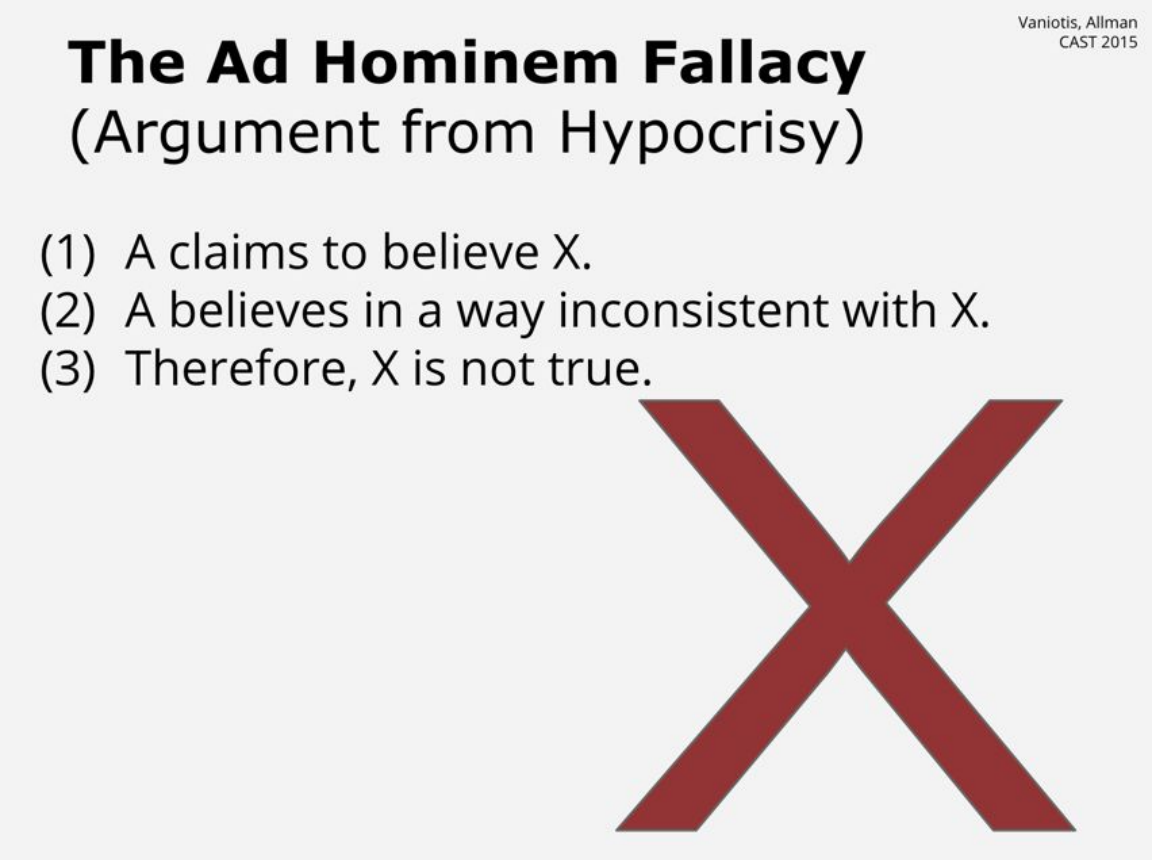
Of course there are plenty of beliefs that even evil, stupid, and ignorant people happen to be correct about.





But another example is more subtle: Let's say you discover that a person believes something because they stand to be enriched if it happens to be true.

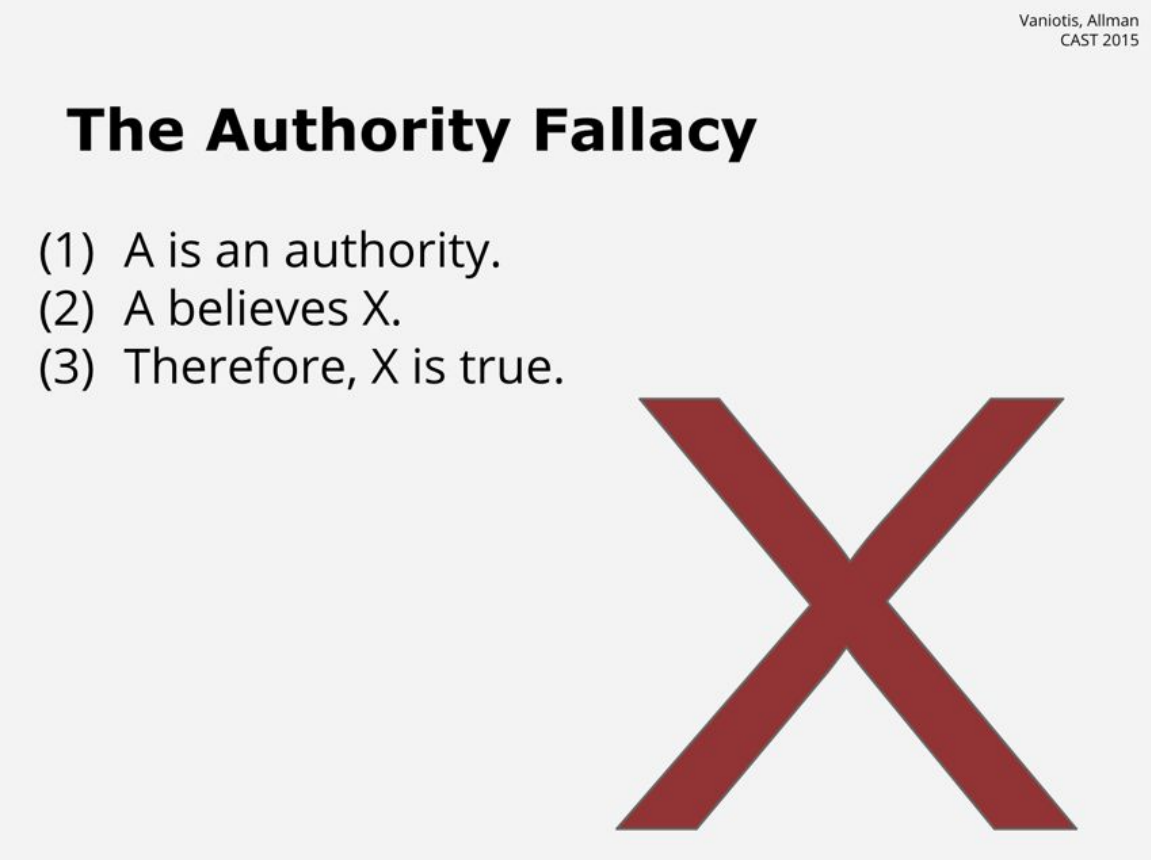
It might be the case that that person doesn't have a good *reason* to believe X and may even be willfully ignoring evidence to the contrary to keep the money coming in. But this doesn't have any bearing on the truth of the matter. X needs to stand or fall on its own merits.



A third form of this fallacy is called the "argument from hypocrisy."

1. A person claims to believe a certain thing,
2. but in their personal life they don't behave like they believe it.
3. Therefore their belief is false.

There is a certain emotional appeal to this argument. We don't like to emulate people who fail to live up to their stated beliefs, and maybe such a person would be a better advocate for their position if their own house was in order. But it doesn't necessarily mean they are wrong in their beliefs. It is easy to examine one's own life and find instances where sincerely held standards or beliefs are difficult to live by. We generally consider people who hold themselves to a high standard to be admirable (even if occasionally they fall). Failures to meet a high bar are not always evidence the bar should be lowered. The conclusion of an argument has to stand on its own evidence, not on anything related to the mental or moral state of the individual making the argument.



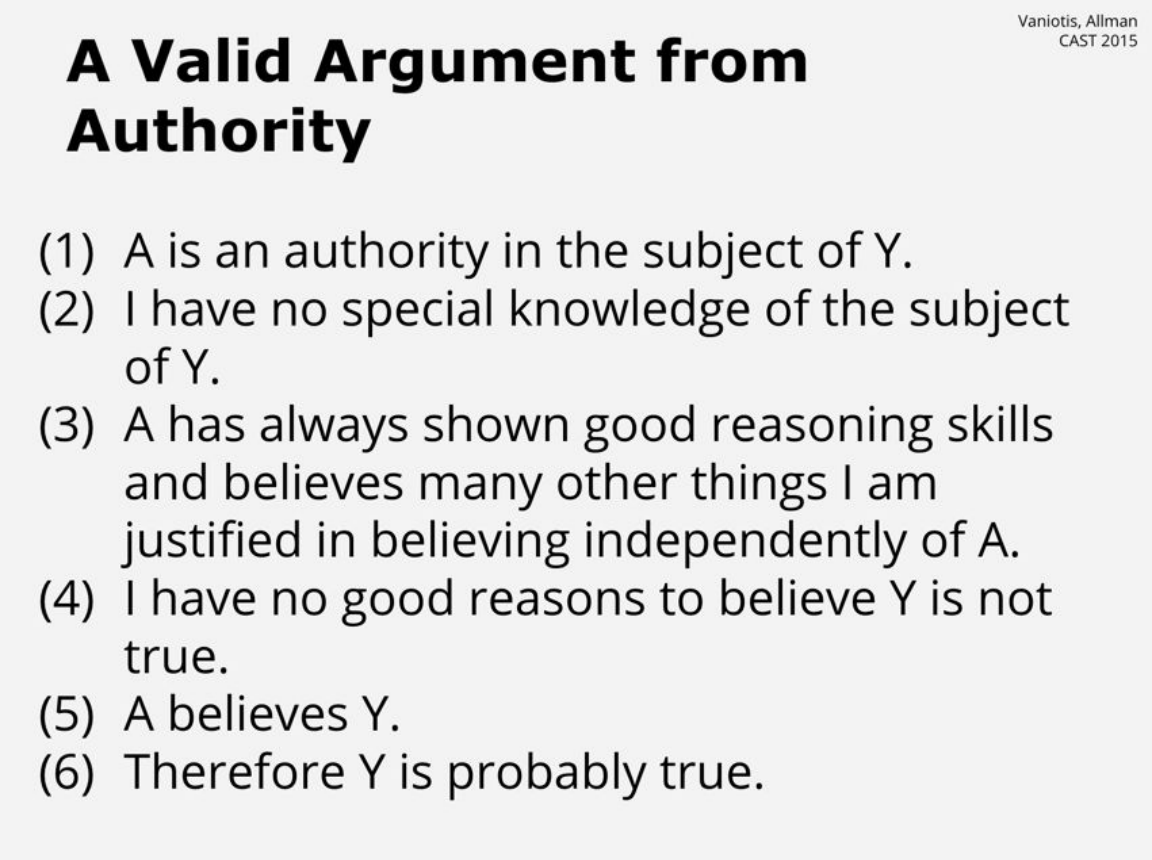
Authority Fallacy

The "Argument from authority" has the form:

1. A person is an authority.
2. The believes something.
3. Therefore that thing is true.

This not the fallacy of choice in the modern age, although it certainly crops up in the celebrity endorsement style of advertising. The weakness in this argument is once again that there is no evidentiary connection between the premises and the conclusion.

This fallacy is better stated as a fallacy of "unjustified authority" or "overreaching authority". Many of our common everyday beliefs are held on the basis of the testimony of other authorities and considering the vast amount of knowledge in the human race that we have not ourselves directly verified it is perfectly reasonable to accept the authority of others in their areas of expertise.



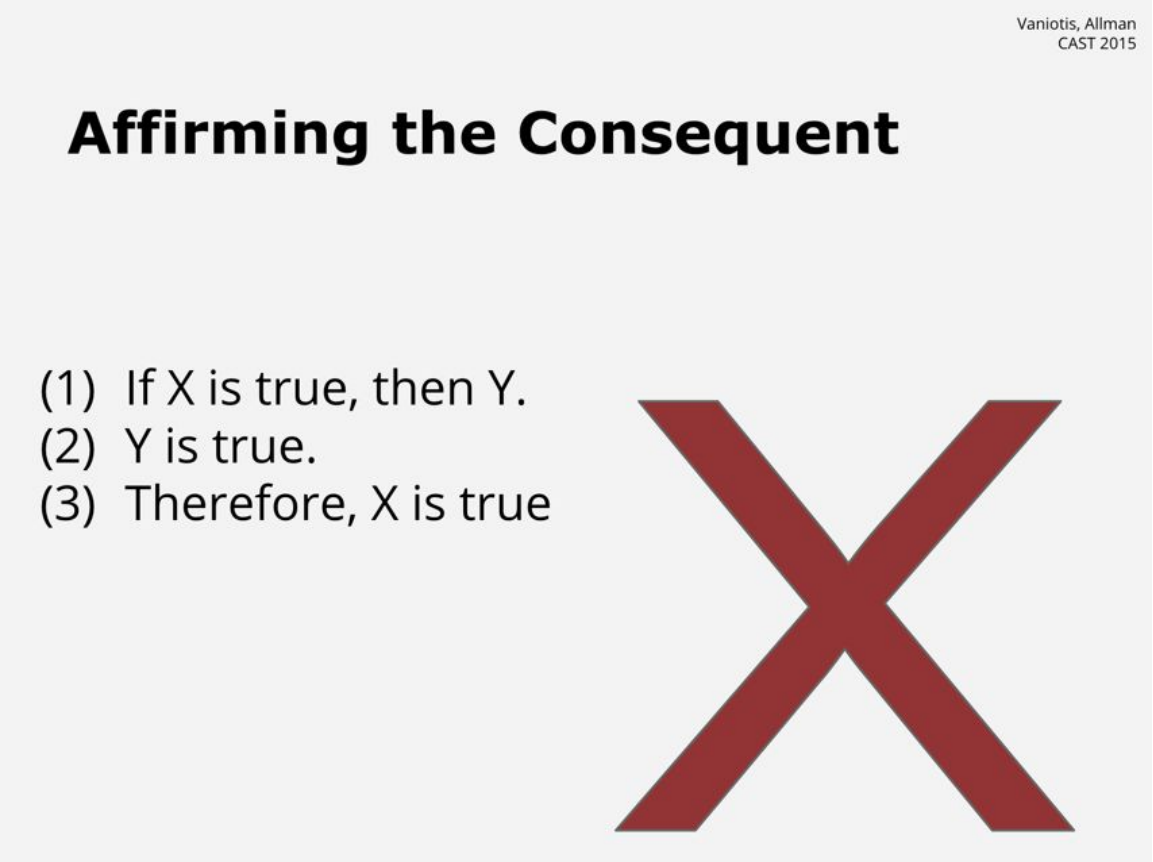
This form of the "argument from authority" is sound and avoids the fallacy:

1. There is an authority in a subject (of which I have no special knowledge) who has always shown good reasoning skills and believes many other things that I am justified in believing.
2. That authority believes something, Y.
3. I also don't have any other good reason to believe that it's not true.
4. Therefore, that belief is probably true.

This is precisely how we came to believe a great many things that are outside our area of direct expertise.

Formal Fallacies

As we turn to formal fallacies, we will see that two of the most common involve giving more power to an "if-then" statement than it has.



Affirming the Consequent

The first "if-then" fallacy is called "Affirming the Consequent". The absurdity of this fallacy is clear when we create a simple example:

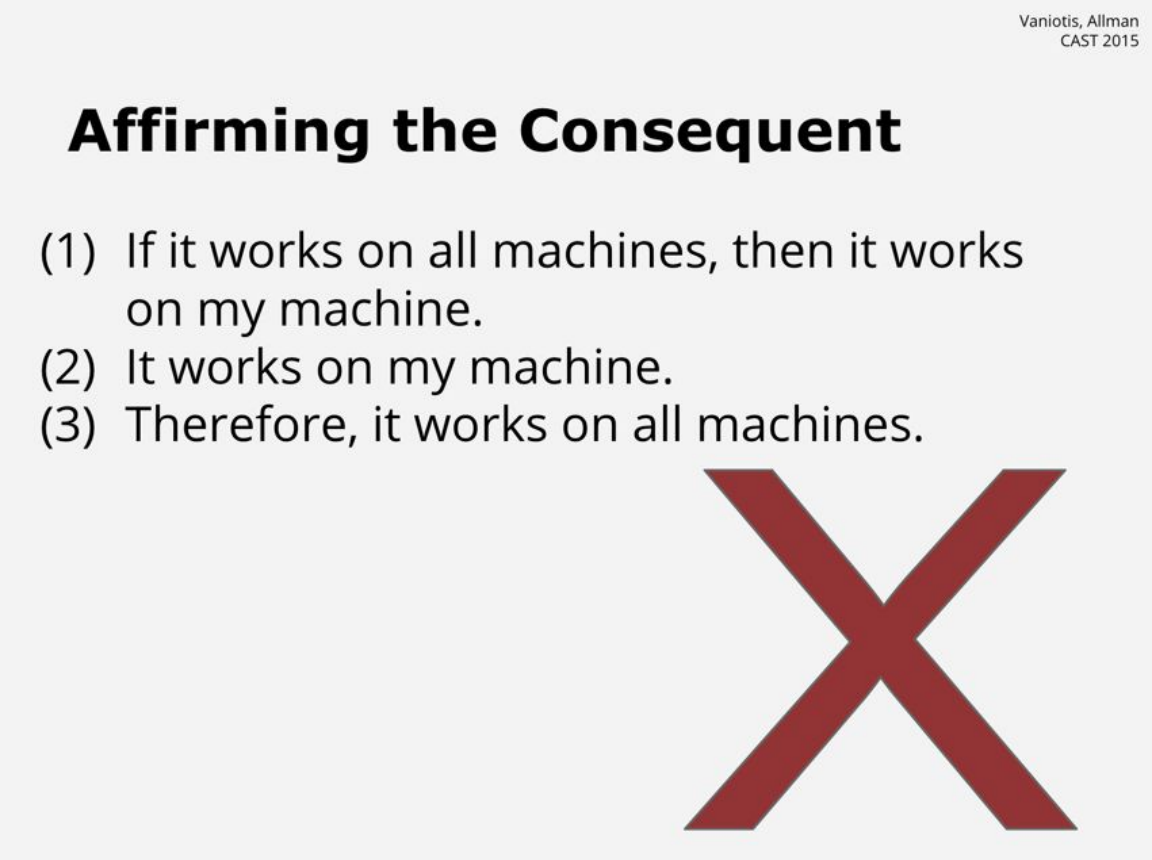
1. If all testers wear ties to work, then Thomas wears a tie to work.
2. Thomas is a tester and wears a tie to work.
3. Therefore, all testers wear ties to work.

A quick poll of this room will suffice to disprove this reasoning.

Automated test results are particularly subject to misinterpretation based on this fallacy.

1. If there is no bug in the software, then I will see the expected results when I execute the test steps.
2. I *do* see the expected results when I execute the test steps.
3. Therefore, there is no bug in the software.

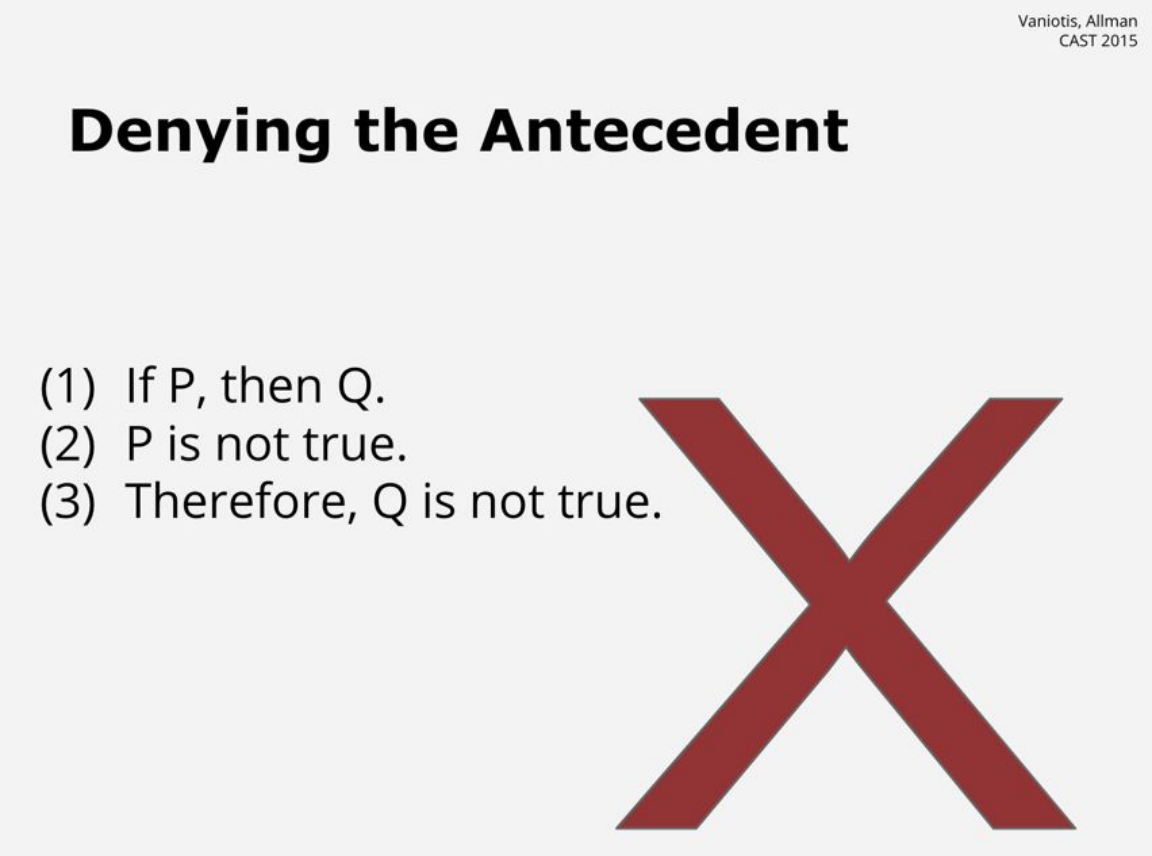
As we discussed before, a single successful test is obviously not enough to prove the absence of bugs.



On a lighter note, we can see that this fallacy is also the favorite of developers!

1. If it works on all machines, it works on my machine.
2. It works on my machine
3. Therefore, it works on all machines.

Denying the Antecedent



A related fallacy also misapplies the scope of a logical implication (an "if-then" statement).

We can illustrate this with another Cucumber calculator example:

1. If ***P*** I entered 50+70, then ***Q*** I will see 120 on the screen.
2. ***P is not true,*** I don't see 120 on the screen.
3. Therefore, ***Q is not true,*** I didn't enter 50+70 (there must be something wrong with my test!)

With toy examples like this, it is hard to imagine such a blunder persisting. But in more complex tests, this kind of fallacious reasoning can leave you with a blind spot for true errors.

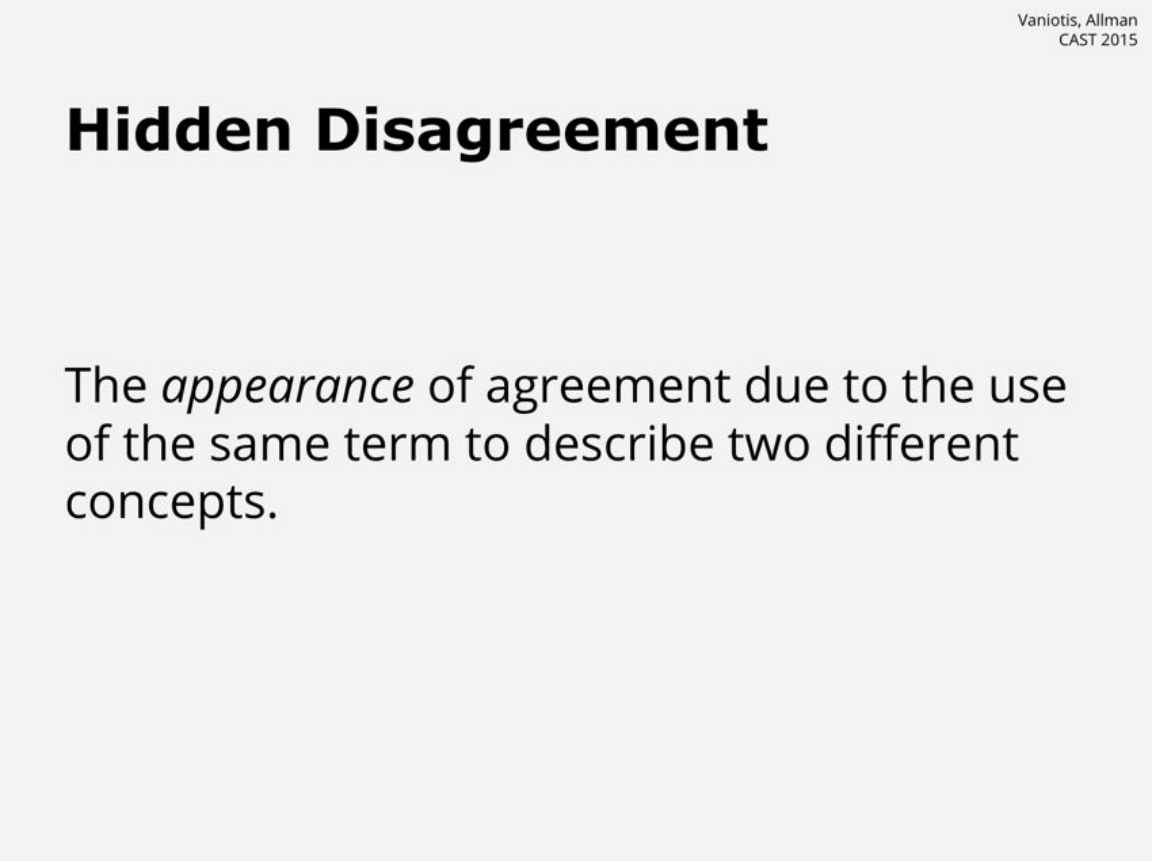
Further fallacies

Just like there are countless design patterns and code smells, there are many more fallacies than we have had a chance to review in this presentation. We encourage

you to research further online - but also warn you also to keep your critical faculties sharp! The label “fallacy” is powerful, so sometimes it is used as a rhetorical bullying tactic to discredit an argument that is actually sound.

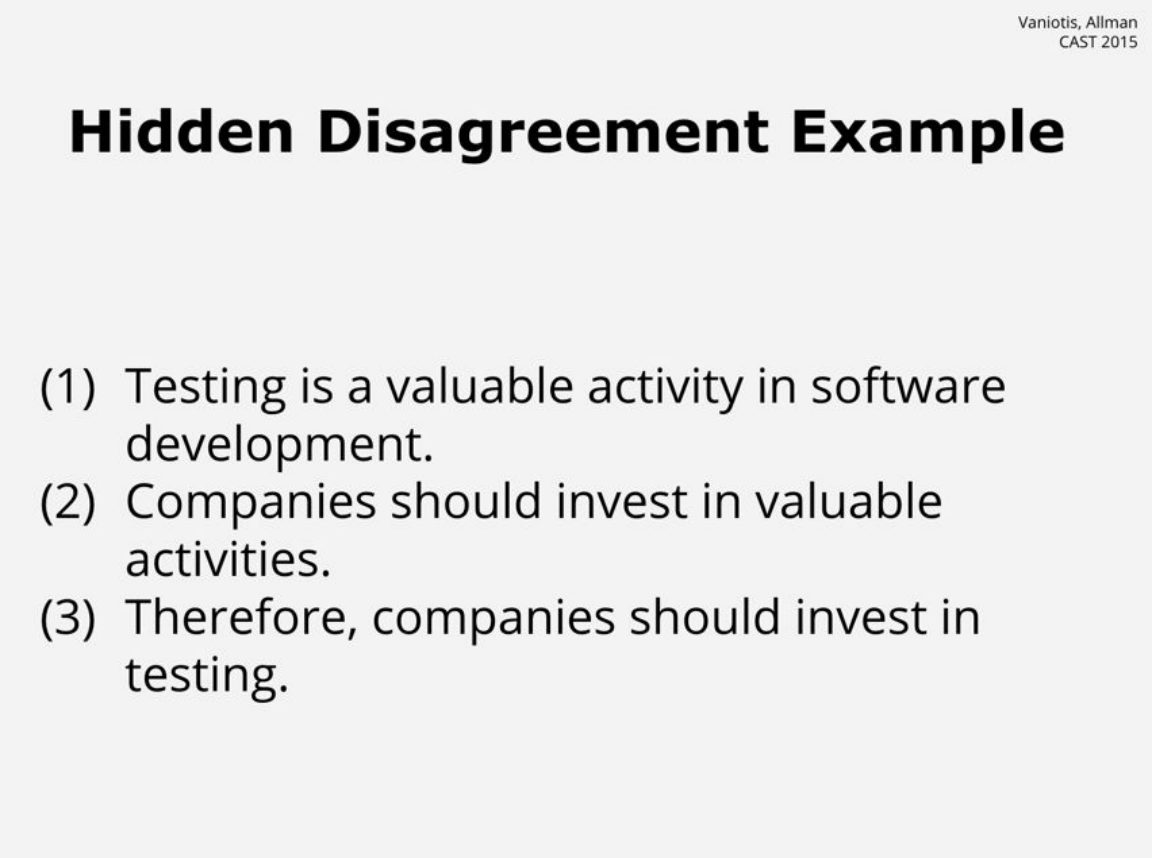
Errors in Communication

We think it is so important to teach the method of argument analysis because it can help to avoid two errors that are poisonous to discourse within a community. Specifically, hidden disagreement, and hidden agreement.



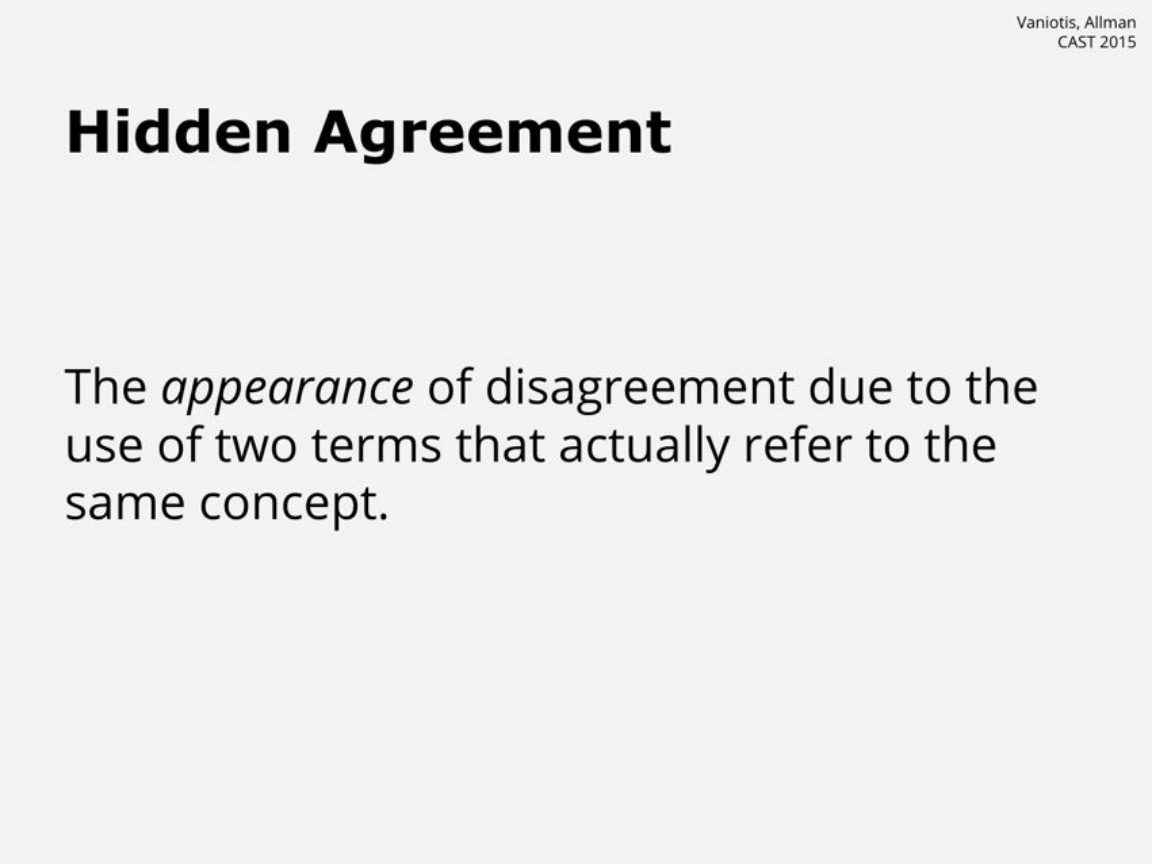
Hidden Disagreement

The concept of “hidden disagreement” refers to dialogue partners who are referring to two **different** concepts but use the **same** word to refer to them.



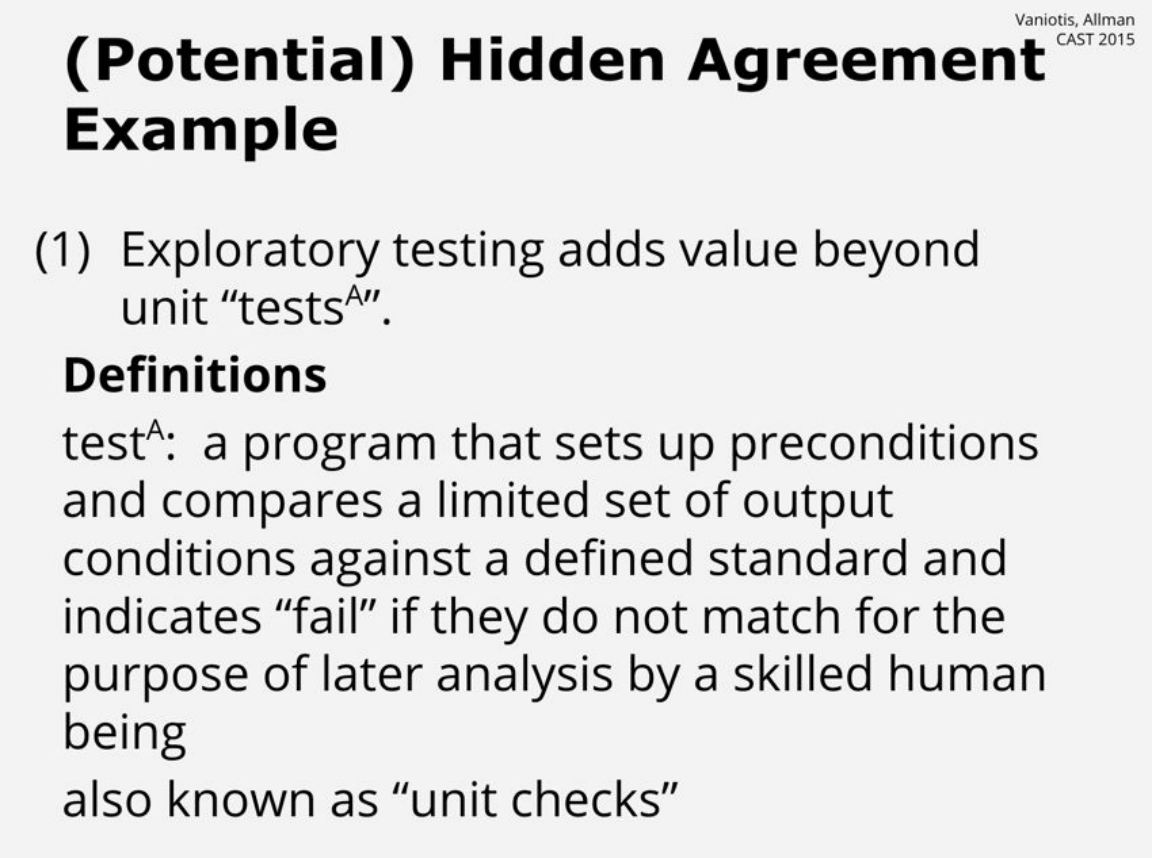
If you take an active member of the context-driven school of software testing, she might make a statement like "Testing is valuable," and even use it in an argument like the one on the slide for why companies should invest in testing. A DevOps-oriented developer might make the same statement, as could a factory school conference presenter -- yet each of these sentences means something significantly different, and the conclusion of the argument is likely to be misinterpreted.

Thus, it is important to know when to disambiguate. When the definition itself is relevant to a conclusion, allowing hidden disagreements to remain hidden can lead to additional stress in later dialog and hurt feelings.



Hidden Agreement

Hidden agreement's main danger is not to the truth, but to the emotional health of arguers and communities. In this case, much energy is expended over questions of wording and distinctions. As we discussed earlier, often the definition of terms is not relevant to an argument, and then allowing hidden agreement to persist avoids unnecessary emotional strain and disunity. Communities in which all the arguers ought to be allies end up divided.



We have considered one instance of "hidden agreement" earlier in this talk when we discussed the case of an argument about whether testing-A (meaning running automated unit checks) is helpful. Evaluating that argument does not necessitate a general agreement about the definition of "testing".

One might consider arguments about whether a bug should be categorized as a "sev-2" or a "sev-3" in contexts where the distinction makes no difference in terms of what actions are taken and there are no practical consequences riding on the label. Or perhaps in a heavily documentation-oriented context, it is possible to imagine debates about whether a particular artifact should be called a "test case" or a "test suite". If there are no differences in interpretation or consequences, then arguing[5] over naming is an unnecessary.

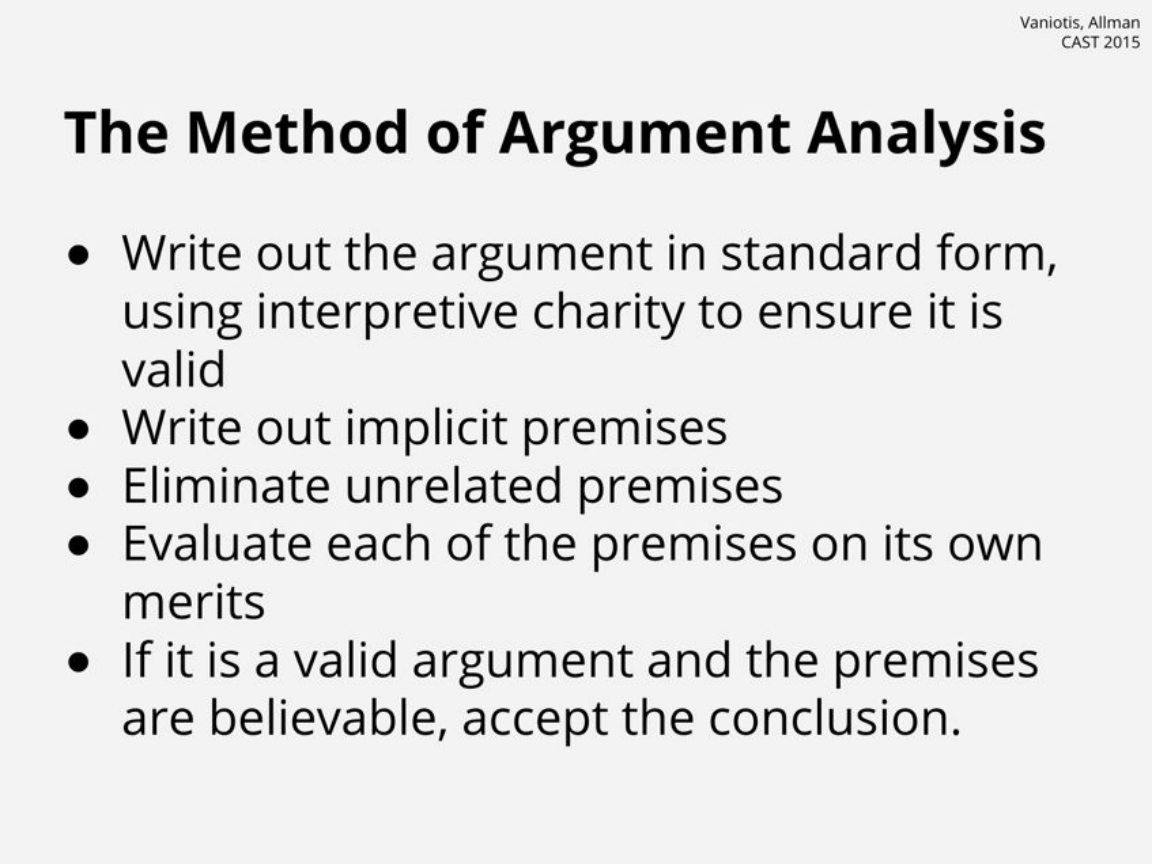
Cases of hidden agreement are one of the few times where the "that's just semantics" dismissal is logically justified. One party or the other ought to graciously allow the "incorrect" naming to the persist in the service of shared truth-seeking.

[5] Even if one has a particularly strong metaphysics of ontology, it seems that as a practical matter one should avoid unnecessary debate about which arbitrary symbol to use for a concept while arguing other points. The argument about what things should be named ought to stand alone.

Conclusion: A Framework for Use

We have now presented a significant set of tools that are useful for both constructing and evaluating an argument. We will conclude by summarizing the method of argument as a series of steps for either evaluating or constructing an argument on your own.

Argument Analysis



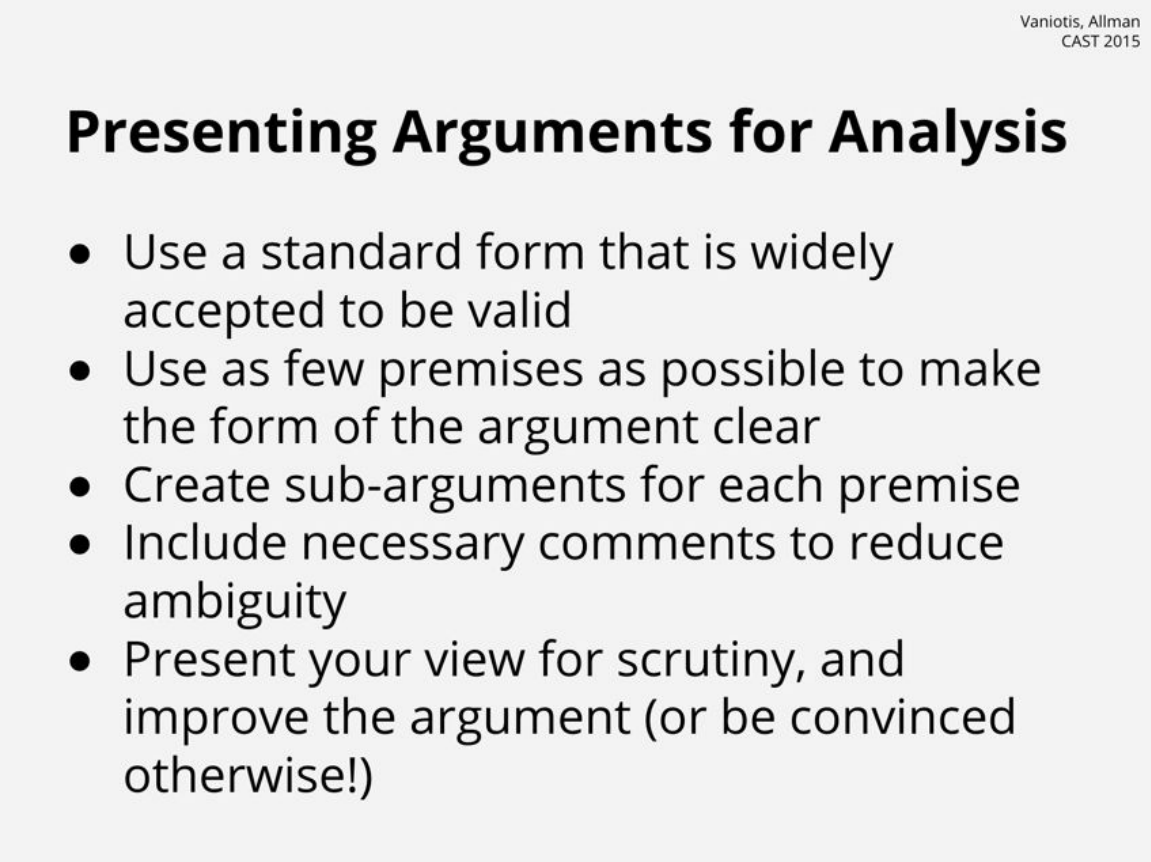
When analyzing an argument, you will want to read through it with a keen eye toward identifying the premises and conclusion, and noting the logical connections that the author is asserting.

Begin by writing the argument in a standard form with numbered premises and conclusions. Most ordinary arguments are logically straightforward, so you can assume the author is *intending* to construct a valid argument. Even if he has not done so successfully; use interpretational charity.

Making the argument valid may require you to insert premises that the author left implicit,[6] or to remove premises that are an unnecessary distraction from deriving the stated conclusion.

Finally, evaluate the premises one by one, as if you were unaware of the conclusion of the argument. If you are an intellectually honest person, it is not sufficient to believe each premise just because you happen to believe the conclusion. Indeed, the argument you are evaluating may not be the strongest possible argument. Remember that rejecting one of the premises only means *this argument* is unsound. It is entirely possible that the conclusion is still true. However, if you find all of the premises compelling and the argument is valid, you are logically compelled to accept the conclusion as true.

Argument Construction



When it comes to your own arguments, we suggest using this disciplined method will help you make your reasoning both compelling and subject to scrutiny in a way

[6] You will often find that your supplied implicit premises differ from the author's and presents a deeper source of disagreement. We have noticed that identifying and arguing about *implied premises* is often where minds are changed in the course of argument.

that advances the field of knowledge, regardless of whether you are speaking to trained philosophers. You may notice in these steps a certain resemblance to the standard academic essay or thesis. Those forms draw on the same tradition of intellectual rigor.

First, write your argument using a standard form. Depending on how formal the setting is, you may even consider writing the main argument as a series of numbered premises and conclusion. Use as few premises as possible so that the reasoning shines through and validity of the argument is not in doubt.

Second, write commentary on each of your premises in the form of evidence as to why the premise should be believed. The heart of your argument will be in the evidence for the premises. Depending on the complexity of your overall point, you may develop these justifications into something resembling full-fledged sub-arguments themselves.

You may also want to include definitions of terms or descriptive context, as we discussed earlier, to avoid ambiguity.

Finally, anticipate possible objections to your argument. Use the replies to these challenges in your justification for the premises, but also consider direct attacks on your conclusion. What is the most compelling reason for someone to disagree with you, and what kind of argument would they construct? Thinking through these counter-arguments will strengthen your own and perhaps suggest new approaches or premises.

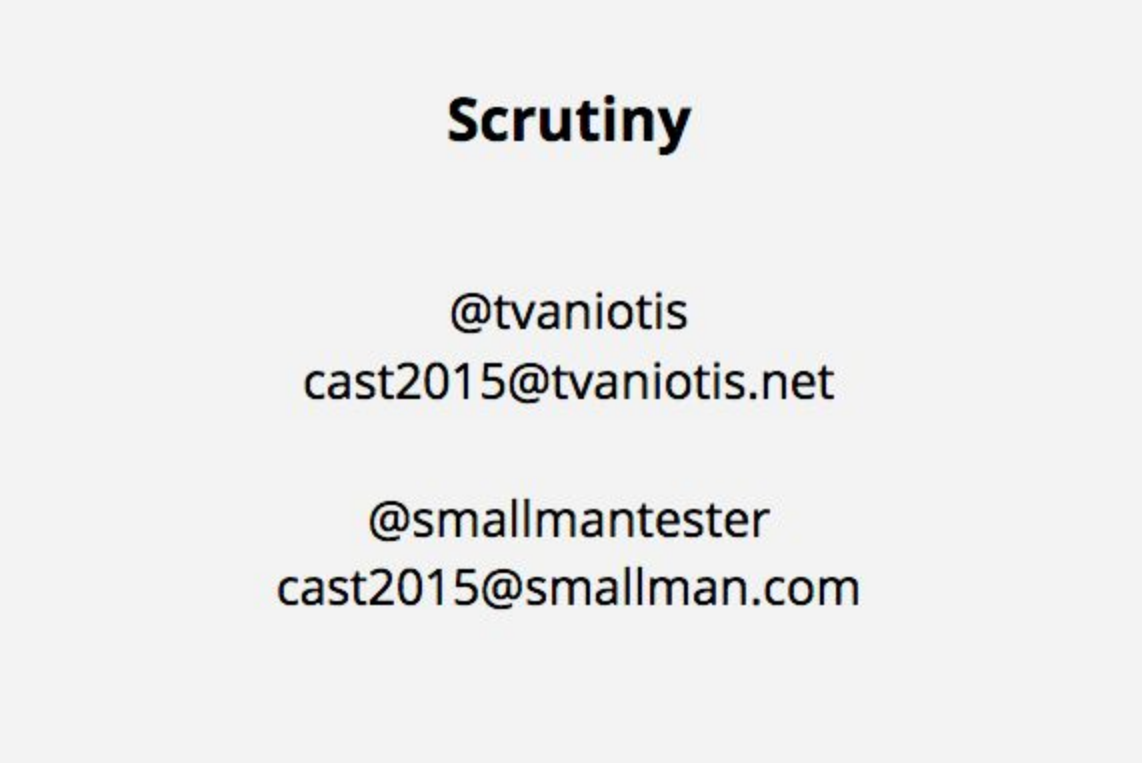
Remember, by using a well-formed valid argument, your readers will be compelled to believe the conclusion if they accept the premises. Thus, you conclude by summarizing your argument and placing it into context.

A final word to testers and software professionals

In conclusion, we do not suggest this highly formalized method be used in every context, nor that it is always the best way to convince others. It may come off as stuffy or condescending if implemented wrongly. But we do advocate for using it as a basis for your own thinking about your profession and everyday life. If you take what you learn through careful analysis, apply common sense and rhetorical flourish, you will be a more compelling communicator even if others don't directly see the architecture behind your thought. By applying the philosophical method to every argument you encounter, you will certainly have a more consistent and confident understanding of your own beliefs and the beliefs of others.

Acknowledgement

Richard Feldman's *Reason and Argument* (Prentice Hall: 1993) was enormously helpful in the preparation of this paper. Thomas Vaniotis is also grateful for the philosophical mentorship that Prof. Feldman offered while Thomas was an undergraduate student at the University of Rochester. We also thank Cem Kaner and Becky Fielder for their review of an early draft of the ideas in this paper and presentation, and the tolerance of our families, coworkers and colleagues.



Appendix: Additional Topics

The following topics were not covered in the CAST 2015 presentation, but may be of interest to the reader. Note that this section of the paper has not been as carefully reviewed as the preceding. Caveat lector.

Structure of Arguments

Implicit Premises in Arguments

When writing out an argument in a standard form, you will often discover that in order for it to be valid, linking premises must be supplied. By making these implicit premises explicit, you provide additional opportunities to evaluate the argument for soundness. Good testers will be able to identify many implicit premises in testing-related arguments. Our tests must have reliable oracles. We must have correct tools to compare oracles to the system under test. Environments must be in the correct states. We must have representative cases and correctly identify what equivalence classes are relevant. It is not always prudent to write out every implicit premise, because in many cases they are not germane to the problem, but just like Rubber Duck Debugging[7] can expose logic errors in code, carefully talking through all the implicit assumptions exposes logic flaws in test design.

Use of statements for multiple purposes

There is nothing intrinsic to a statement that makes it a premise or a conclusion. By convention, we precede conclusions with "Therefore," but often the same sentence that is the conclusion of one argument ends up being the premise of another. We observe this in Cucumber tests as well. Richard Lawrence points out[8] that the "Given," "And," and "When" of Cucumber simply precede interchangeable step definitions by convention, and "It's fairly common for today's When to be tomorrow's Given, so this is a nice feature."

The logical links between premises and conclusions are where all the interest lies in argument, just as the logical consequences of Given/When/Then is the power of test reporting from Cucumber scripts.

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[7] *The Pragmatic Programmer,* cited in Wikipedia (http://en.wikipedia.org/wiki/Rubber_duck_debugging)

[8] http://www.agileforall.com/2010/07/just-enough-regular-expressions-for-cucumber/

Paradox

Paradox is a mental state where you believe the premises of an argument to be true and the reasoning appears sound, but you nonetheless disbelieve the conclusion. Philosophers disagree on whether there are true paradoxes, but suffice it to say that in most ordinary cases you are compelled to take one of three approaches to resolve a paradox: reject one of the premises, find a fallacy in the argument, or reject the conclusion.

Additional Fallacies

Question Begging

Although sometimes people use the term "to beg the question" to mean "to raise a question", in its technical sense, "question begging" means to make an argument where the conclusion is directly included in the premises. As a formal matter, question begging is a valid argument:

1. X is true.
2. Another way of saying X is true.
3. Therefore, X is true.

Usually question-begging does not present itself so obviously. The premises are supposed to provide *evidence* for the conclusion, but if the premises are simply the conclusion in different words, they don't provide any additional evidence or justification for your belief in the conclusion. Sometimes this is disguised more heavily by including misleading premises or unnecessary leaps of logic to hide the question-begging. Carefully writing out the argument in a standard logical form exposes this fallacy.

No True Scotsman

There is a common form of "generalization" in a valid argument that says:

1. All X are Y.
2. A is an X.
3. Therefore, A is Y.

Through some simple logical manipulation, we can note that in this case if B is not Y, premise (1) is not true, and the argument is unsound. By finding at least one counter example, we now have clear evidence that not *all* X are Y. This is related to the common mathematical method of "proof by contradiction".

Often in debate, though, a participant in an argument will retort that "B is not a *true* Y", implicitly rewriting the argument. The classic case (which gives the fallacy its name), is something like this:

1. All Scotsmen are noble.
2. Anthony is a Scottsman.
3. Anthony is not noble because he cheats at cards.

An authentic pursuer of the truth would consider (3) evidence against premise (1), but instead says "Anthony is not a *true* Scotsman because a *true* Scotsman doesn't cheat at cards." This becomes a case of defining the category in such a way that the counterexample is excluded and is a form of implicit question-begging. Yet in some cases, the line of discussion does become useful in elucidating the terms of definition in an argument (as we discussed above). In our Scotsman case, if the Scots truly don't play cards in a way that is relevant to our argument, the fact that he plays cards may be enough to exclude him as a counter-example.

Conjunction Fallacy

The Conjunction Fallacy is an error in probabilistic reasoning that misleads us into believing that a more specific combination of conditions is more probable than a more general one.

The canonical example of this fallacy is as follows:[9]

(1) Linda is 31 years old, single, outspoken, bright, majored in philosophy, concerned with social justice and involved in anti-nuclear demonstrations

(2) Therefore, "Linda is a bank teller and is active in the feminist movement" is more probable than "Linda is a bank teller."

The authors, Tversky & Kahneman, showed experimentally that most people believe (2) on the basis of (1), although the rules of probability contradict this intuitive reasoning. Probabilities of two independent variables are always less than the probability of each, because they are multiplied.

The importance of recognizing this fallacy is twofold: first, it can be deliberately deployed to confuse, as in the case of someone deliberately including extraneous information in a prediction in order to make it more plausible. Second, awareness that we have a cognitive bias to incorrectly assign probabilities in conjunction teaches us to simplify our probabilistic arguments to avoid the error.

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[9] Tversky & Kahneman (1983)

Argument from Fallacy

When one first learns about fallacies, the "argument from fallacy" trap arises: believing that because someone else holds a belief on the basis of poor judgement, that belief must be false, or more formally:

1. Many people believe Y for fallacious reasons.
2. Therefore, Y is not true.

A few examples shed light onto why this is not a reliable way of reasoning: it is easy to imagine some people believing something that happens to be true just because they like (or dislike) the proponent of the belief. Their poor reasoning for a belief has no bearing on the truth of the matter. You may, of course, wish to correct them on their faulty reasoning and investigate the matter further when deciding what to believe, but it should not influence your own position on the matter.

Fallacy of Four Terms

Hidden disagreement also underlies a common philosophical joke, which illustrates a real logical fallacy, called the "fallacy of four terms", or the equivocation fallacy.

1. Nothing is better than eternal happiness.
2. A ham sandwich is better than nothing.
3. A ham sandwich is better than eternal happiness

The flaw in this argument is that there is shallow agreement about the definition of "nothing". In the first premise, the phrase "nothing is better" refers to the non-existence of a thing with greater value. Yet in the second, "better than nothing" refers to the *de minimis* value of a particular thing. So in reality, there is no logical connection between the two premises.

Epistemology: Belief, Justification, and Knowledge

The relationship between persons and statements is considered in the philosophical field of "**epistemology**". You might consider the following topics as a starting point for further reading:

A person has a choice when encountering a statement: accepting it (believing it), rejecting it, or withholding judgement. The classic account of **belief** holds that it is an intellectual act of assent - an act of the will.

The question of whether one *should* believe a particular statement is a matter of **justification.** Generally justification for a belief is based on evidence. Types of

evidence include testimony, statistics, causal reasoning, chained argumentation, and so forth. Broader than evidence strictly understood, is the question of an **account of justification:** how does one justify beliefs in the context of all the other beliefs that one has? Some of the major accounts of justification include evidentialism, coherentisim, reliabilism, foundationalism, and warrant. Theories of justification are used to counter philosophical **skepticism,** which debates the possibility of certainty or even rational belief in some or all statements. They are also used in consideration of **relativism,** the view that all facts (or particulars sort of facts) are relative to a particular person or culture. An extreme version of relativism would say that the statement represented by "The sun orbits the earth" was true in 300BC, but it is not true today. People tend to think that moral or aesthetic facts are more likely to be relative than scientific facts (although there are reasons to think this is also philosophically weak: for example "It is wrong to exterminate people based on their racial/religious identity" seems to have a universal truth-value regardless of person or culture). In the analysis of argument, relativist concerns can be considered another implicit part of context that is present in the mapping from sentence to statements and thus relativism (even if true) does not require the abandonment of rational discourse. We simply require each sentence to have a qualifier of "relative to whom" and then proceed to argue about the truth of that fully-qualified statement.

Finally, there is the matter of **knowledge.** The traditional definition of knowledge is "justified, true, belief." Note that this implies that "knowledge" exists only in relation to a subject who has beliefs - whereas truth is objective, a fact about the external world. An argument about a matter of fact therefore generally hinges on which position is justified. (The "JTB" definition of knowledge has been challenged by philosopher Edmund Gettier, see Thomas Vaniotis's CAST 2013 emerging topics talk for more details in the context of software testing).

Non-Deductive Reasoning

This paper has focused on deductive reasoning, that is, reasoning from premises to conclusions. Deductive reasoning is foundational for our rational belief that the other forms of reasoning work, yet as a practical matter, we rarely rely solely on deduction to form our beliefs about the world. A simple extension to deductive reasoning is inductive reasoning (sometimes called "probabilistic reasoning"), where certain forms of "cogent" argument (the inductive version of "valid") can be inductively sound if they yield a conclusion that is more probable than not. Reasoning inspired by the Bayseian interpretation of statistics has been used in

epistemic theories. Furthermore, as Scott Allman discussed at CAST 2009, abductive reasoning, "reasoning from surprising facts", is commonly used in software testing. Observing a surprising fact may be a reason to believe the circumstances that would make such a fact common are true.

Further Reading

If this topic has piqued your interest in formal philosophy, we strongly recommend the Stanford Encyclopedia of Philosophy (plato.stanford.edu), whose articles are encyclopedic, thus accessible to non-professionals and useful as an introduction, yet peer-reviewed by academics and written with technical precision. The citations in plato.stanford.edu articles are of immense value.

For book-length treatments, consider:

Feldman, Richard. *Reason and Argument.* 2nd ed. Upper Saddle River, N.J.: Prentice Hall, 1999.

Feldman, Richard. *Epistemology.* Upper Saddle River, N.J.: Prentice Hall, 2003.