

THINKING CRITICALLY – WORKSHEET 1
“RELIABLE” SOURCES, EVIDENCE, PROOF, AND KNOWLEDGE

READ: We want our sources of information to be “reliable”. This applies to all our sources, for any information, in general. But we can use an example to motivate how to do it.

Part I: Who Dunit? – Work in groups to answer the following questions on a whiteboard. Be prepared to support your answers with the rest of the class.

You’re a rookie detective and arrive on a crime scene with two people involved: person D is dead, person A is alive and claims self defense. Your only evidence in this made-up scenario is witness testimony.

1. By yourselves, answer the following questions to help brainstorm a list of qualities you’d want your witness testimony (sources of information) to have, which would make the testimony “reliable”.
 - a. Do you want your witness to be biased – to have a view or motivation that could make them either lie, or misinterpret what they remember happening? Can you always tell if they’re biased?

WANT NO BIAS, BUT THIS IS HARD TO TELL. LOOK FOR THEIR WORLDVIEW OR HOW THEY MIGHT BENEFIT FROM ONE SIDE OR ANOTHER.

- b. Do you want your witness’s testimony to make internal sense? For example, if you interview them on two separate days, do you want both accounts to stay consistent or to change with time?

WANT INTERNAL SENSE. WANT IT TO BE CONSISTENT. NOT ALWAYS EASY TO TELL EITHER.

- c. Do you hope your witness really did witness it or just hear about it from someone else? Do you want your witness to see what happened or just hear it happen when they weren’t looking?

WANT TO BE A DIRECT WITNESS. WANT THEM TO SEE IT, HEARING HARDER TO INTERPRET.

- d. Do you want to have just one witness or multiple witnesses?

WANT MULTIPLE WITNESSES.

- e. If you have multiple witnesses, would you want them to generally agree or generally disagree on what happened? Note: eyewitnesses are never completely accurate/consistent in the real world.

WANT GOOD AGREEMENT.

- f. Would you prefer all your witnesses spoke with each other before talking to you or that their testimonies were independent of each other?

WANT THEM TO BE INDEPENDENT OF EACH OTHER.

WRITE THESE DOWN ON A WHITEBOARD AND PREPARE TO DISCUSS THEM AS A CLASS

2. Together in groups, answer the related questions for each of those above but to figure out what qualities you'd want in sources of information you find on the Internet about some claim that might be true or false (e.g. soft margarine is "healthier" for the typical person than soft butter). Don't pick a specific claim; just imagine a generic statement you want to know is true or false.
- a. Do you want your sources to be biased? What could you look for to tell if a source is likely biased or not?

WANT UNBIASED (NEUTRAL). IT'S HARD TO TELL, BUT YOU COULD LOOK AT .EDU SITES OR SCIENCE INSTITUTIONS. LOOK FOR THEIR AFFILIATIONS, EMOTIONAL LANGUAGE AND HOW THOROUGHLY THEY ANALYZE THE CLAIM.

- b. Do you want your sources to make internal sense, to be internally consistent? To be sure they are internally consistent, do you want them to explain their conclusion, backing their argument up with references, or just state their conclusion, without supporting info?

WANT INTERNAL SENSE, CONSISTENCY. EASIEST TO TELL IF THEY EXPLAIN THEIR CONCLUSIONS AND INCLUDE REFERENCES

- c. Do you hope, ideally, that your sources are primary sources or secondary sources, or do you want both? Look up these terms if you are not sure what they mean.

WANT PRIMARY SOURCES, AT LEAST. SECONDARY SOURCES ARE OKAY IF THEY ADD FURTHER ANALYSIS, BUT ARE NOT A SUBSTITUTE.

- d. Do you want, ideally, to have just one source or multiple sources reporting on the same claim?

MULTIPLE SOURCES (VERIFIABLE)

- e. If you have multiple sources, would you want them to generally agree or generally disagree about whether the claim is true or false?

GENERALLY AGREE (VERIFIED, ONLY IF INDEPENDENT)

- f. Would you prefer all your sources copied each other, or that they presented independent analyses of the evidence for and against the claim?

INDEPENDENT SOURCES. WITH THE INTERNET, THIS CAN BE VERY HARD TO TELL (MANY JUST LINK TO EACH OTHER) BUT YOU WANT IT AS CLOSE TO THE ORIGINAL, PRIMARY SOURCE AS POSSIBLE.

3. In groups: By default, we all tend to stop looking when we think we have the answer, which is sometimes just the first source we find, other times it's when we confirm what we thought was true beforehand (this is called confirmation bias). What is a strategy you could use to help overcome this tendency?

SEEK OUT OPPOSING VIEWPOINTS. ONCE YOU FIND AN ANSWER, DON'T STOP UNTIL YOU TRY TO DISPROVE IT – CHECK WHICH IS MOST UNBIASED AND CONSISTENT. This can be VERY time consuming. Note that some things have a higher bar of evidence than others. Proving UFOs exist should require A LOT more/better evidence than locating Canada.

WRITE THESE DOWN ON A WHITEBOARD AND PREPARE TO DISCUSS THEM AS A CLASS

4. In groups:

- a. If you actually had all of these the qualities from question (2) in your sources of info and you used your strategy you came up with from question (3) to find them, does that guarantee your info is correct or is there some possibility it is still wrong?

COULD STILL BE WRONG, NO GUARANTEE

- b. If you think you have a “reliable” source, is there any possibility the information from that source is wrong? (A rephrasing of “a”)

COULD STILL BE WRONG, NO GUARANTEE

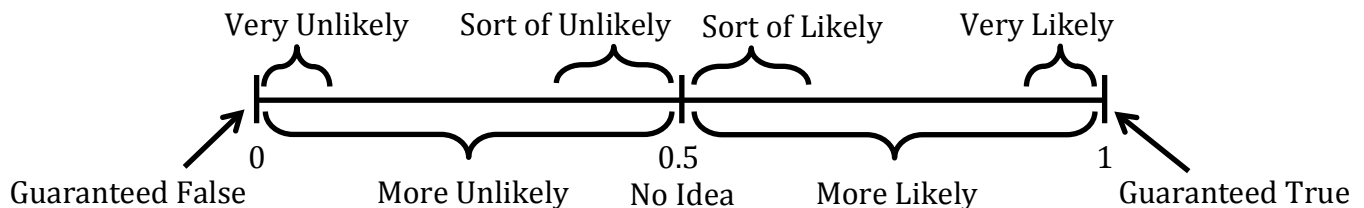
- c. If it doesn’t guarantee correctness, why even try to find reliable sources?

BECAUSE IT MAKES IT MORE LIKELY TO BE TRUE (MORE RELIABLE) THAN IF YOU DON’T USE GOOD SOURCES.

- d. With all this in mind, is it better to say some source is “reliable” or to qualify it by saying it is “pretty reliable”, “highly reliable”, etc.? Is it misleading to just say a source is “reliable”?

BETTER TO SAY QUALIFY IT BY HOW RELIABLE YOU THINK IT IS. OTHERWISE, IT IS MISLEADING: THERE’S ALWAYS A CHANCE OF A MISTAKE.

5. Think of a spectrum: a number line ranging from 0 to 1 like the one shown below. Let this number line represent how likely you think some claim is to be true or false.



If you rate some claim at a 0, you think it is guaranteed false. If you rate it at a 1, you think it is guaranteed true. If you rate it at a 0.5, you have absolutely no idea if it’s true or false (and so on: see above).

- a. If I flip a coin, look at the result and cover it up so you can’t see, roughly how certain should you be about which side is facing up, based on the spectrum above? **~0.5, NO REAL IDEA**
- b. In the coin flip scenario, where I flipped the coin and looked, roughly how certain should I be about which side is facing up, based on the spectrum above? **VERY LIKELY: 0.99999...9, ONLY A VERY SLIGHT CHANCE OF A MISTAKE**
- c. How likely should you rate the claim that the Earth is roughly a sphere (not flat)? **VERY LIKELY: 0.99999**
- d. How likely should you rate the claim that it is impossible to have a square circle? **Basically 1 (could quibble)**
- e. Based on what’s been covered, what should we keep in mind when someone says a source is “reliable” or “highly reliable” when it comes to some claim?

WE CAN NEVER REACH 1 – GUARANTEED TRUTH. ALWAYS SOME CHANCE IT COULD BE WRONG, EVEN IF IT’S SMALL

Basically nothing is UNCONDITIONALLY guaranteed. All depends on argument, and only math and logic give you guarantees, but they are conditional.

WRITE ANSWERS TO 4 AND 5 ON A WHITEBOARD AND PREPARE TO DISCUSS WITH THE CLASS

6. Suppose you have two conflicting pieces of evidence, from the original scenario in question 1 (person D is dead, person A is alive):

- a. An eyewitness “swears” person A defended themselves, and
- b. A recording from a nearby security camera showing person A was the attacker.

Which is more reliable? Is either absolutely foolproof? How can you tell which conclusion is more likely?

***THE RECORDING IS MORE RELIABLE. NEITHER FOOLPROOF. COULD HAVE BEEN A PREMEDITATED CONSPIRACY TO FRAME PERSON B WITH EDITED FOOTAGE AND GET PERSON D KILLED. SEEMS VERY UNLIKELY, BUT POSSIBLE.**

***VERY TECHNICAL, I’LL GIVE YOU A TAKE-AWAY AT THE END**

***IN GENERAL: BAYESIAN HYPOTHESIS TESTING. TWO TAKE-AWAYS, whether something is true depends on:**

1) PLAUSIBILITY, given everything we know (prior probability), and

2) EVIDENCE showing the data is more likely under one hypothesis than all others.

***Here: Hypothesis = person A is the attacker**

Data1: eyewitness saying person A defended self. Eyewitness are often wrong, could go either way

Data 2: recordings are reliable UNLESS someone deliberately staged it, which is very low probability. So the data is more likely given person A is the attacker.

Plausibility: person A being the attacker or not, not considering the data, is roughly equal.

Conclusion: Data 1 inconclusive, Data 2 strong support of Hypothesis = person A is the attacker, so this is likely true.

7. When someone demands that you provide “proof” that some claim is true, what should you really be striving for? (Leading questions: Is proof ever absolute? How can we think of the word “proof” so that a bunch of good evidence for some claim can be considered proof?)

PROOF IS NEVER ABSOLUTE; JUST WANT GOOD EVIDENCE (PROBLEM OF INDUCTION IN PHILOSOPHY). PROOF SHOULD BE THOUGHT OF AS A BUNCH OF REALLY REALLY GOOD EVIDENCE, WITH NO UNEXPLAINABLE COUNTEREVIDENCE.

WRITE ANSWERS TO 6 AND 7 ON A WHITEBOARD AND PREPARE TO DISCUSS WITH THE CLASS

Part II: Finding Those Sources

Now you have a general tactic, but sometimes finding the information is the hard part. Let’s assume you’re using the Internet. If you want printed sources, you can find which one(s) you want on the Internet, first.

8. Compile a list of Google search tips and techniques you could use to find whatever you’re looking for more quickly and efficiently. (If you don’t use Google for your search engine, look for equivalent information for the one you prefer.)

- a. Use your general tactic from the last Part of this activity to help find the most effective, most reliable, and as many as you can of the possible Google search tips/techniques.

For example, your favorite website’s search engine might be really terrible. How could you use Google to search this site instead?

- **List of keywords site:website.com**
- **List of keywords filetype:pdf**
- **“List of keywords” does search for exact phrase**
- **Put a (-) in front of words you want to exclude – No great success when tested**
- **Google tabs (Web, Images, Shopping, Search Tools)**
- **Numeric range: X..Y, how to use with price?**
- **Calculator, unit conversion**
- **Google knowledge graph, knowledge – the box that pops at the top – can be flawed**

9. Let's put your Google skills along with your newfound method of finding reliable source to the test.
- Suppose your favorite website's search engine is really terrible. How could you use Google to search this site instead?

your keywords here site:myfavoritewebsite.com

- What is the current scientific definition of a second, the unit measuring duration of time?
The second is the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium 133 atom

- What is the current scientific definition of a meter, the unit measuring distance?
The meter is the length of the path travelled by light in vacuum during a time interval of $1/299\,792\,458$ of a second.

- An object that swings back and forth is called a pendulum. What does the period of a pendulum mean?

How long it takes the thing to complete one full cycle.

- What did Galileo use to measure that the period of a pendulum doesn't depend on how widely it swings back and forth? I'm not asking what was the pendulum he used, or what he used the pendulum to measure, but what did he compare the swing period to, thinking that it gave a regular interval of time?

His heart beat/pulse.

- How long did it take for the current Guinness world record holder for most claps in a minute to complete just one of those claps, on average, during his championship clap session? (This involves a little math.)

**Guinness world records lists Eli Bishop, at 1020 times/minute (Aug 22, 2016).
 $60\text{sec}/1020\text{claps} = 6/102 = 3/51 = 1/17$ of a second = 0.0588seconds/clap**

- What is the running time of the movie Batman v. Superman: Dawn of Justice (2016)? (Use hours and minutes, not seconds.)

**151min = 2h31min QUICK GOOGLING REVEALS 3h3min on Aug 22, 2016. It's wrong!
I just watched it and its basically only Google's knowledge tree that's wrong.**

- Is dihydrogen monoxide relatively safe to ingest?
It's water. It's pretty darn safe.

- Is the Pacific Northwest Tree Octopus really endangered?
It doesn't really exist

Part III: What Science Cares About – The Scope of Science

We are concerned with knowing what is true or not about the natural universe – not matters of pure opinion. Understanding the difference is important. Most people are pretty good with this. Whether the Earth is flat is a matter of objective fact. What the “best” color is, is a matter of opinion. Value judgments, assigning value to something, is inherently subjective.

10. To “know” what’s true or not assumes a good working definition of “knowledge” and nobody honestly says they “know” something if they don’t believe it. So we also need a good working definition of “belief”. Use the skills you learned throughout all the previous parts to find a good, foundational definition of “belief” and “knowledge”. Look at multiple independent sources and be sure they make sense. We want these to be as simple as possible (but not simpler), general, and free from emotional baggage. Start by listing multiple (maybe 5 or more) different definitions of knowledge from different sources, then compare and contrast them to argue which one is best.

“Belief” – An idea somebody thinks is true.

“Knowledge” – A well-justified, true, belief.

(This is not my own definition – adapted from Plato.) So to be legitimately called “knowledge” someone has to:

- 1. Believe it.**
- 2. It has to actually be true, to the best anybody can argue.**
- 3. That someone must be able to support it, well, PERSONALLY.**

This last criterion is the kicker, and will be useful to remember throughout the course: if you can’t support your idea well, you can’t call it knowledge. It’s just a belief. The answers you get in class, on homework, during a lab or on an exam, you want to be able to support them well, yourself, personally - not just by saying that I (the teacher) said so, or that it sounds good. Really think how you “know”.

11. Once we’ve agreed upon a definition of knowledge, use this concept to come up with a good definition of a “fact”. (Help: does a fact have to have absolutely everyone agreeing with it to be a legitimate fact? Is there such thing as a fact nobody ever supported with really, really good evidence, or argument, or conclusive demonstration?)

A fact is some idea that has been supported with a very, very high degree of evidence, or in the case of pure math/logic, a well-vetted proof.

Questionable whether it depends on how widely known it is. Sometimes widely known things should not be called facts.

Some may have said it was a fact that the Earth is at the center of the Universe, but they were wrong - it was not supported by evidence, though most people thought it was true. The evidence definition is better.