Scientific thinking in daily life

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Scientific thinking and scientific temper

- Science need not be restricted to our work/job, can help us with thinking through things in daily life as well
  - Analyze arguments rationally to take logical decisions
  - Identify and avoid incorrect reasoning in arguments
  - Correctly understand and interpret statistics, probability
  - Scientific temper in daily life
  - Clarity of thought in verbal and written communication
- Reasoning happens via groups of statements called as arguments
  - A set of observations followed by a conclusion

Reasoning via arguments

- An **argument** has: one or more **premises** / observations / evidence / reasons, and a resulting **conclusion** inferred from the premises
- Example of an argument: "Identical twins often have different IQ scores. Yet these twins inherit the same genes. So environment must play some part in determining a person's IQ"
  - Premise: Identical twins often have different IQ scores
  - Premise: Identical twins inherit the same genes
  - Conclusion: Environment must play a part in determining IQ
- Identify premises and conclusion here
  - "The world has moved to online classes in the past few years due to the pandemic. But student learning and engagement have been observed to be sub-optimal in the online mode. In-person classes are better than online classes any day."

Unstated premises and conclusions

- Premises and conclusion in an argument usually identified via cue words
  - Premises identified by words like “because”, “since”
  - Conclusion identified by words such as “therefore, consequently”
- Some arguments can have **unstated, implied** premises or conclusions also
- Argument: “Over the past 200 years, humans have been responsible for releasing large amounts of greenhouse gases into the atmosphere. Therefore, human activities have become a major source of global warming. ”
  - Premise: Humans have released greenhouse gases for past 200 years
  - Unstated premise: Greenhouse gases cause global warming
  - Conclusion: Human activities are a major source of global warming

Argument vs. exposition

- Argument are group of statements with evidence/ reasons leading to a conclusion, and goal is to convince the reader of something
- Exposition: group of statements describing or explaining something, without necessarily leading to a conclusion, or aiming to convince
- Expositions and explanations may be part of arguments, as part of evidence for the conclusion
  - Premise: The ground is wet
  - Explanation: The best explanation for this fact is that it has rained last night
  - Conclusion: Therefore, it would have rained last night
  - Final argument: The ground is wet, so it would have rained last night

Cogent vs. fallacious reasoning

- Reasoning in an argument can be **cogent** (good) or **fallacious** (bad)
- Cogent reasoning:
  - Premises are justified, based on well-founded knowledge
  - All relevant information and premises have been considered
  - Our reasoning and inference methodology is correct
- If these conditions not met, reasoning can be fallacious
  - Wrong premises (premises are false, questionable, or incomplete)
  - Wrong inference (drawing conclusions incorrectly from given premises)

Justified premises for cogent reasoning

- For cogent reasoning, premises should be justified. How?
  - Based on known facts or observations
  - Based on well accepted beliefs, opinions, background knowledge
- Argument: "Serena Williams has won 23 grand slam titles, so she is one of the great tennis players of our age."
  - Premise: Serena has won 23 grand slams (known fact)
  - Premise: Winning grand slams is possible only for great players (well accepted belief)
  - Conclusion: Serena is one of the great tennis players of our age
- Questionable premises can lead to fallacious reasoning
  - Premise: The weather prediction says it will rain tomorrow
  - Conclusion: It will surely rain tomorrow
  - Implied, questionable premise that the weather prediction is always accurate

Biased opinions

- Fallacious reasoning if premises based on biased opinions which are not justifiable
- Individuals tend to have more loyalty to "in-group" (tribe, religion, caste, race, sex, nationality, friends, family, even our own self, …) vs. "out-group"
  - Judging ourselves and our in-groups more favorably than we deserve, rationalization of own bad behavior, selective blindness to own flaws
  - Judging out-groups unfavorably, propagating prejudices and stereotypes
  - Wanting more than fair share of something for in-group, and less for out-group
- Confirmation bias: we only notice/recall/look for things that confirm to our point of view, and ignore evidence that contradicts our point of view
- Wishful thinking and self deception: believing in what makes us feel good or feel in control, in spite of no evidence for such beliefs
- Hindsight bias: thinking that past events were more predictable than they are

Why biased opinions?

- As per evolutionary psychology, human instincts honed over millions of years of evolution to ensure survival in harsh, unknown conditions
  - All "biases" discussed earlier had (have?) social and psychological benefits
- Quick judgements and stereotypes, even if not fully accurate, helped with decision making under constrained thinking time
  - Example: better to be suspicious rather than friendly to an unknown stranger in tribal societies?
- Loyalty to in-group improved social cohesion, led to stable societies
  - Are such instincts useful in today's day and age, with mostly peaceful and well-connected societies? Logical thinking also part of evolution of thought?
- Self deception helps even today to cope with vagaries of life
  - Example: "My son is so smart but still he did not clear the exam. The exam must surely be rigged."

One-sided arguments

- Fallacious reasoning where premises are cherry picked to support one side of the argument, ignoring evidence for the other side
- A **balanced** argument presents all relevant premises, both for and against the conclusion, and then argues why the conclusion is justified given all evidence
  - Based on weighing both sides and deciding whose case stronger
  - Must fairly present and argue against the opposite side, not ignore it
- Why is evidence from one side missed?
  - Unintentionally, due to inherent biases, we do not register evidence that goes against our cherished views
  - Intentionally, to mislead on purpose, for selfish motives or vested interests

One-sided argument: example

- Example: discussion of whether attendance must be compulsory in classes
  - Instructor: "Students bunk classes to waste time in unproductive activities. Attending classes will make the students learn better. So we must mandate attendance." (partly correct, attending classes will help most students, but some may manage without attending too)
  - Student: "Instructors teach us irrelevant information in a boring manner. Attending classes is a waste of time. So there should be no compulsory attendance." (partly correct, some instructors may teach irrelevant content, but many do try to make their classes useful)
  - A good argument presents both points of view, and draws a balanced conclusion, e.g., attendance is made compulsory because the benefits will outweigh the costs for many students, but feedback is taken from students to make classes useful and fun

Appeal to authority

- Arguments with premises where justification based on authority of experts
  - Not every premise can be verified by us, so we must rely on experts
  - Fallacious reasoning if expert opinion is wrong
- Why can expert opinions be wrong?
  - Expert has some bias or vested interests in propagating a lie (e.g., politically motivated statements from journalists for personal gains)
  - Experts in one field aren't necessarily experts in another (e.g., trusting a religious authority for scientific matters)
  - Experts may be drawing conclusions from limited evidence (e.g., making claims about a drug's efficacy based on limited data)
- Example: "Experts X, Y, and Z say that climate change is a hoax. So we must not worry about it."

Appeal to emotions

- Fallacious reasoning where premises based on appealing to emotions, instead of presenting facts or using logic
  - Emotions by themselves are not bad, but using them in logical arguments is
  - Know when to use logic and when to use emotion in decision making
- Example: an advertisement promoting a clothing product not because it serves its intended purpose but because it will make you feel confident
- Example: "The man I saw in the hospital was crying out loud in agony. The doctors must not be doing a very good job. Let's go somewhere else."
  - Emotions in such arguments may cause incorrect decision making

Ad hominem argument

- Fallacious reasoning where premises employ personal attacks on opponent, rather than facts relevant to the argument
  - Ad hominem means "to the person"
  - Attacks on a person's character, or other personal traits
  - Guilt by association: suspecting the opponent because of association with a particular ideology, organization, sex, religion, or caste
- Political discourse is full of ad hominem arguments: politicians often attack the opposition leaders, without evaluating their arguments or policies
  - A female politician proposes a sound policy but is attacked based on her gender, saying women won't know much about the world or policy matters

Irrelevant premises

- Fallacious reasoning where premises contain reasons that are not really relevant to the conclusion
  - The premises may be true and relevant in another argument, but not this one
  - Also called red herring fallacy or non sequitur (means "does not follow")
- Example: "In the past two hundred years, modern technology has greatly improved the life expectancy of humans. Therefore, industrialization has been good for the environment."
  - Improving life expectancy has nothing to do with the environment
- Example: "Politician X is a great father, a loving husband, and a dutiful son. His family has served us for generations. He will be a great leader."
  - No reasons presented to support the claim of great leadership

Inconsistent premises

- Fallacious reasoning where argument has contradicting premises
  - Making contradictory statements at different times or places, or to different sets of audiences, either on purpose or unintentionally
  - Not realizing that tradeoffs are inevitable: you cannot have your cake and eat it too
- Plenty of examples in political discourse and daily life
  - Politicians promise a lot of things (e.g., jobs, welfare schemes), but also promise things that will hinder their efforts to realize these plans (e.g., tax cuts, freebies)
  - Citizens want government to do a lot of things for them (e.g., provide stable electricity), but are not willing to pay the price (e.g., opposition to power sector reforms, to make electricity distribution profitable and accountable)
- Note that change of opinion with time after due consideration is not inconsistency, and is healthy

Begging the question

- Fallacious reasoning where premise assumes conclusion is true and derives from it, resulting in circular reasoning
  - Begging the question means leaving the question unanswered
- Example: tobacco smoke causes cancer because tobacco has many carcinogenic (= cancer causing) chemicals
- Example: science cannot explain everything because there are things beyond what science can explain
  - It may indeed be true that science cannot explain everything, but the above argument does not provide any good reasons to draw that conclusion

Strawman argument

- Fallacious reasoning where premise misrepresents opposition's position via oversimplification, and argues against the weaker position
- Example: an activist opposes the development of a polluting factory, but is labelled as anti-development and anti-industrial progress
  - Over-simplification: the activist never opposed development as a whole, only a specific case with negative consequences
- Example: government decides to provide subsidies to accelerate technology development, but is accused of helping crony capitalists
  - Better to make a more nuanced argument about specific companies that have received funding but are known to have shady dealings

False dilemma / either-or fallacy

- Fallacious reasoning where premises describe only extreme positions, ignoring the middle ground
  - Many things in life are neither black nor white, but many shades of grey
- Example: "Human progress is causing ecological collapse on earth. The earth will survive only if the human race is destroyed."
  - The two possible options in the argument are that humans stay on earth and cause ecological collapse, or they disappear from earth altogether
  - But there is a middle ground where humans take a sustainable approach to development, and live in harmony with mother earth, so the conclusion is false
- Example: "You either work hard and crack JEE, or you stay miserable the rest of your life" (no, there exist other options too!)

Premises with missing context

- Some premises do not provide enough background context to judge their truth, possibly leading to fallacious reasoning
  - Background may be skipped intentionally, to mislead on purpose
- Example: claims on net zero carbon emissions fail to mention the specific details of how emission reduction is achieved, whether a real reduction is made or just some carbon accounting hacks employed
- Example: a drug company claims that its drug has cured a disease, without mentioning the various adverse side effects found

Incorrect statistics: approximations

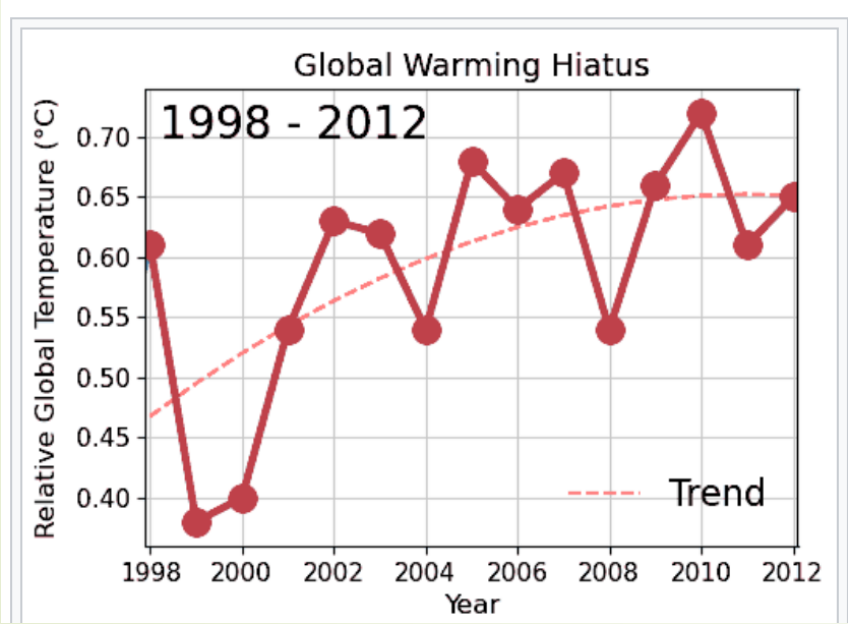
- Fallacious reasoning if premises based on incorrect statistics
  - Quote attributed to Mark Twain "There are lies, damned lies, and statistics."
- Some statistics measure very complex phenomenon, hard to get accurate estimates, numbers are only rough approximations at best
  - Example: Gross Domestic Product (GDP) of an economy calculated using many estimates and approximations
  - Example: Rankings of colleges use questionable metrics that may not always be correlated with quality, e.g., proportion of foreign faculty/students
  - Example: Covid-19 mortality rate is hard to calculate, especially in the middle of the pandemic, when health workers are occupied. Also, ambiguity in whether death caused due to Covid or not

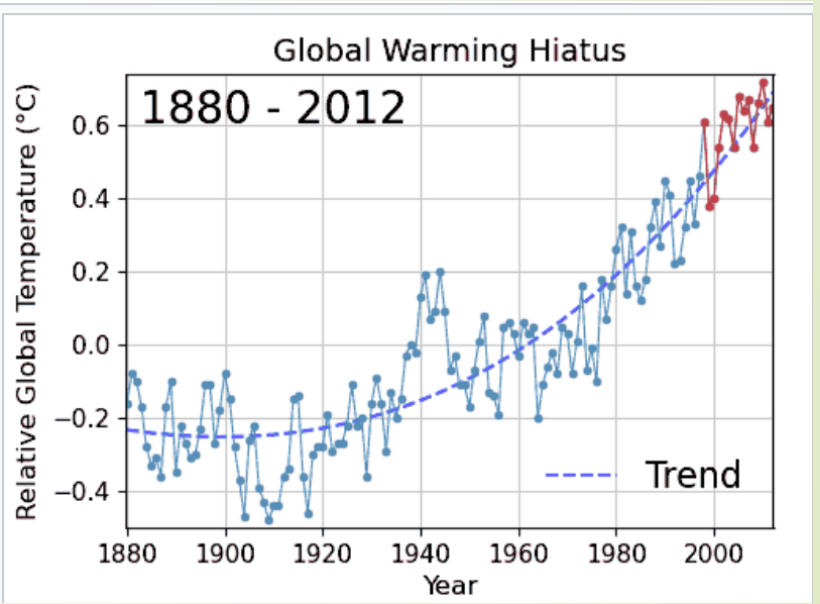
Incorrect statistics: missing normalization

- When reporting statistics, we need to normalize numbers to a proper baseline in order to draw correct conclusions
  - GDP numbers should be adjusted for inflation, purchasing power parity (PPP)
  - Counts related to population should be normalized by the total population
- Example: "India has over 5 million children under 5 years of age who are malnourished, the highest in the world."
  - India also has one of the highest number of children under 5 years of age, so this statistic by itself does not convey how serious the issue is
- Example: which is a better metric to convey the seriousness of a disease outbreak? Number of cases per day per million people? Total number of cases per day? Cumulative number of cases since the beginning of the outbreak?
  - We often reported the total cumulative cases during the Covid pandemic

Incorrect statistics: misleading graphs

- Graphs can be misleading and lead to wrong conclusion
- Example: Looking at a subset of global temperature time series can lead us to believe that global warming is slowing down, when it isn't
- More examples: y-axis not starting at zero, extrapolation across missing points, incorrect scale of axis, axis scale shifting midway, ..





Incorrect statistics: biased sampling

- Incorrect statistics due to biases during the sampling process
- **Confirmation bias**: we tend to collect statistics that favor our cherished point of view (intentionally or unintentionally)
  - May lead to asking loaded questions (that suggest an answer) in surveys
  - Example: researchers aiming to establish the widespread prevalence of unhappy marriages may ask the question "why are you unhappy in your marriage?" rather than asking "are you happy in your marriage?"
- **Selection bias**: the way we select samples may bias towards one conclusion
  - Example: in survey to check on the availability of high speed Internet for online classes during Covid-19 pandemic, only those with good Internet are likely to check the emails and fill the survey
- **Survivorship bias**: selecting samples that passed a test, ignoring those that didn't
  - To look for weaker areas of fighter airplanes in WW2, it was suggested to add extra armor at places where the planes that returned were not hit (because planes that were hit at those points didn't return and fell)

Caveat: premises based on values

- Some premises based on values that differ across people and cultures, cannot easily judge if justified or not
  - Moral, cultural, religious values: views on drugs, alcohol, cruelty to animals, …
  - Nature or personality: is the glass half full or half empty? Conservative or liberal? Risk taking or risk averse?
  - World view: should we optimize for the individual or for the society?
- When such premises are part of argument, no consensus on what is cogent and what is fallacious. How to handle such disagreements?
  - Ensure all other causes for fallacious reasoning eliminated
  - People may change opinions when they hear the other side (some may not)
  - If disagreement still persists, accept differences, find a reasonable compromise, agree to disagree respectfully

Wrong premises: summary

- Fallacious reasoning due to questionable or incomplete premises
  - Personal biases, one-sided evidence
  - Use of dubious experts, emotions, personal attacks
  - Irrelevant, inconsistent, or empty premises
  - Distortions due to oversimplification, missing context, black-and-white view
  - Biased samples, incorrect statistics
- How to avoid?
  - Learn to think objectively, be aware of your biases and try to overcome them
  - Seek and understand evidence even from the opposite side with an open mind
  - Independently verify premises, from multiple sources
  - Scrutinize statistics and graphs carefully with skepticism
- Next: valid ways of inferring conclusions

Deduction

- Arguments based on the principle of deduction are one of the most common
  - Premise: If A then B, A implies B, A→ B (grand slam win → great player)
  - Premise: A is true (Serena won many grand slams)
  - Conclusion: B is true (Serena is a great player)
  - Example: "Copper conducts electricity. This wire is made of copper. Therefore, this wire conducts electricity."
- Let's revisit the example: "My son is so smart but still he did not clear the exam. The exam must surely be rigged."
  - Implied premise: If smart people do not clear the exam, the exam is rigged
  - Premise: My son is smart (questionable); premise: he did not clear the exam (fact)
  - Conclusion: The exam is rigged
  - This is a valid deduction, even though one of the premises is questionable, and hence the conclusion itself may be questionable (garbage in, garbage out)

Valid deductive arguments

- **Modus ponens:** If A then B. A is true. So B is true.
  - Example: Use of a non-biodegradable material will cause significant pollution. Plastic is non-biodegradable. So, use of plastic causes pollution.
- **Modus tollens:** If A then B. Not B. So not A.
  - Example: If women are intellectually inferior to men, there won't be many women scientists. We have a lot of women scientists today. So women are not inferior to men.
- **Hypothetical syllogism:** If A then B. If B then C. Therefore, if A then C.
  - Example: Attending classes increases your understanding. Good understanding leads to good grades. So attending classes helps improve your grades.
- **Disjunctive syllogism:** A or B. Not A. Therefore B.
  - Example: Andromeda is either a star in our Milky way or it is another galaxy altogether. Andromeda is too far away to be in Milky way. So Andromeda is another galaxy.

Invalid deductions

- Confusing **necessary** and **sufficient** conditions, e.g., consider if A then B
  - Sufficient condition: A is sufficient for B, or happening of A always guarantees B
  - Necessary conditions are necessary for the event to occur, but do not guarantee it. Happening of B is necessary for A, but not sufficient
  - Example: "If X is a human, then X is mortal." Being human is a sufficient condition for being mortal, but being mortal is only necessary condition for being human
- Fallacy of **denying the antecedent**: If A then B. Not A. So not B.
  - Example: "If we have a private ownership of property, there will be widespread poverty and inequality. Communism gets rid of private ownership. So there will be no poverty or inequality with communism."
- Fallacy of **affirming the consequent**: If A then B. B is true. So A is true.
  - Example: "If the sun is in the sky, then I can see clearly. I can see clearly now. So the sun must be up." (not true, can be seeing clearly with a torch at night too)

Induction

- Inductive arguments based on generalizing from a set of observations using enumerative, analogical, or statistical induction
  - Premises: a set of observations on a sample
  - Conclusion: generalization on a larger target group
  - Example: "Every time I ate at this restaurant, the food was excellent. So this is a great place to have dinner tonight."
- **Strong** (valid) inductive arguments have a large enough sample that is a good representation of the underlying target group, allow to draw a conclusion with reasonably high confidence
- **Weak** (invalid) inductive arguments only provide weak support to conclusion, based on a sample that does not fully represent the target group

Weak inductive arguments

- **Hasty generalization**: drawing a conclusion based on a small sample, especially in a non-homogenous group
  - Example: "8 out of 10 citizens in a neighborhood view the government unfavorably. Therefore, 80% of the country thinks the government is bad."
  - Example: "I met a person belonging to a certain caste/religion/race a few years ago and he was very mean and arrogant. That entire group is very mean."
- **Biased samples**: drawing conclusions from a sample that is not representative of the entire target group
  - Example: In a survey to assess feedback on a course, most voluntary responses will be students who have a complaint, and those who are happy with the course may stay silent, leading to a wrong conclusion that the course is running badly
  - Example: Sometimes, arguments in a public discourse can be hijacked by a vocal minority, that does not represent the silent majority

Inference to the best explanation

- Form of inductive argument where we put together all known facts, propose a cause or explanation that best explains all the facts, and this leads to the conclusion of the argument
  - Example of how Sherlock Holmes infers theories about people or crime scenes by putting together various observations
- No guarantee of correctness, other possible explanations may be missed
- Incorrect inferences not possible if insufficient data and confounding factors
  - Example: "2022 saw 12% excess deaths as compared to the baseline rate in many countries. The excess deaths are due to <insert pet peeve>." People draw different conclusions from such statistics, blaming Covid itself, side effects of Covid vaccines or drugs, lockdowns, loss of jobs, government policies, denial of medical care for non-covid illnesses, etc for the excess deaths, based on their individual opinions
  - Example: people of a certain race/group are disproportionately jailed because they are prone to crimes due to their socio-economic background or because the justice system is biased against them? What is cause and effect?

More types of arguments: syllogisms

- **Categorical proposition** indicates a relationship between a subject class / group and a predicate class / group
  - Universal affirmative: All humans are mortal
  - Universal negative: No human can fly
  - Particular affirmative: Some humans have blue eyes
  - Particular negative: Some humans are not good runners
- **Syllogism**: argument with three categorical propositions, two premises and one conclusion
  - Valid syllogism: All doctors have bad handwriting. He has a good handwriting, so he is not a doctor (may not be true in reality, but is valid by the rules)
  - Invalid syllogism: All cats have fur. All cats are animals. So all animals have fur
  - Invalid syllogism: Some humans are good runners. Some good runners have four legs. So some humans have four legs

Slippery slope

- Method of inference where we extrapolate one event into a chain of events via a series of deductions, leading to a conclusion
  - The extrapolated events may or may not occur, so the slippery slope arguments can turn out to be visionary or just fear mongering
- Example: "Once we start allowing foreigners into this country, there will soon be so many of them that they will completely wipe out our culture."
  - Many examples from history where this argument turned out to be true/false
- Example: "Once we allow foreign companies to setup factories in India, the competition will hurt Indian industries. Our own industries will shut down and this will lead to widespread poverty"
- Example: "If we reduce the passing grade from 50% to 30%, students will keep demanding further reductions until we end up passing everyone."

Incorrect extrapolation

- Incorrect inferences possible when we extrapolate from conclusion to another related conclusion
- Fallacy of composition: concluding that something should have a property because all of its constituent elements have that property
  - Example: "College X has some of the smartest students and faculty in the country, so it is a great college."
  - May be true, but the conclusion does not follow from premises. What if college X has a major drugs problem?
- Fallacy of division: concluding that because something has the property, all of its constituent elements should also have that property
  - Example: "College X is the best college in the country. Every teacher there must be a brilliant teacher."

False equivalence

- Drawing an incorrect conclusion based on a false analogy between two things that are not really comparable ("apples and oranges")
- Example: "Modern science is not that much better than ancient science. Ancient science couldn't explain many things about the universe, and neither can we today with modern science."
  - Misses the point that ancient science couldn't explain many more things that modern science can now explain. The two are not really comparable
- Example: "Political leader X ordered a military strike that killed civilians. He is a modern day Hitler."
  - Scale and scope of violence is different by many orders of magnitude
- Example: "Vegetarians are hypocrites. They kill plants too."
  - The amount of pain felt by plants and animals may not be comparable

False equivalence in statistics

- False equivalence can be a problem when comparing statistics that are not comparable
- Example: "The population of Australia is less than 3 crores, while we are over 130 crore Indians. Yet, Australia has won 46 medals in Tokyo 2020 Olympics while we won only 7. We are a lazy country."
  - Two countries not comparable in terms of resources available for the average sportsperson
- Example: "Inequality as measured by the Gini index is higher in the US than in India. So the poor are much better off in India than in the US."
  - Even if US is more unequal, the poor in the US have much higher absolute levels of income, and hence better standard of living

Two wrongs make a right

- Fallacious reasoning where we justify a wrong by pointing out a similar wrong perpetrated by others
  - Sometimes, the second wrong is genuinely required to counter the first (e.g., killing someone in self defense when attacked), but not always
  - Leads to a cascade of wrongs, and we lose track of who started it all
- Example: students justify cheating in exams, saying everyone else does it
  - Justified as "common practice" when enough people use this reasoning to commit wrongs one after the other
- Example: tribal / religious wars where group X justifies crimes committed on group Y, because group Y did similar things to them in the past
  - Need to evolve other mechanisms to seek justice

Appeal to ignorance

- Using absence of evidence as evidence for absence in an argument
  - When there is insufficient information to support a hypothesis, we must admit we do not know, but we cannot use it as a reason to believe the opposite
  - Okay to be agnostic, i.e., neither believe nor disbelieve, until enough proof found
  - If evidence not found after sincerely searching for a reasonable time, then it is okay to conclude that the opposite may be true (e.g., planet Vulcan)
- Example: "There is no intelligent life anywhere else in the universe, because we haven't found any so far."
- Example: "This new policy by the government has shown no significant benefits in the past year. It is useless and must be scrapped."
  - Wait for a reasonable period of time before drawing the conclusion

Unrealistic expectations

- Fallacy of judging something as abnormal without having a proper expectation set for what is normal
  - Expectations not in alignment with system capacity and processing times
  - Expecting imperfect solutions to work perfectly (many solutions change the odds but do not solve a problem fully)
- Example: "I have been waiting for 3 months and I still haven't received my Covid-19 vaccine. The government is very inefficient."
  - If we produce X crore vaccine doses a month, how many months will it take to vaccinate the entire eligible population? Is the wait time reasonable or not?
- Example: "I do not see any improvement in the weakest students of the class in spite of providing extra help sessions in the course."
  - Having help sessions may be increasing the number of students following the material, not magically fixing the problems of all students.

Wrong interpretation of probability

- Probability is long term relative frequency of an event over entire population
  - Poor understanding of probability can lead to wrong inferences
- Gambler's fallacy: believing that short term frequencies should match probability
  - Example: Assuming equal probabilities of heads and tails in a coin toss, what is probability of a tail after a string of heads? It is still 0.5
- Personal probability: perceived probability values may be higher or lower than true value, depending on perceptions of fear or optimism
  - Example: someone who has never seen cancer in the close family may believe his/her risk of cancer is very low, may believe risk of other personal fears is higher
- Not understanding expected value of a probability distribution
  - Example: A life expectancy of 40 years does not mean everyone drops dead at 40
- Coincidences do happen, no paranormal explanations needed

Misinterpreting conditional probabilities

- Conditional probabilities: probability of events given other information can be frequently misinterpreted
- Example: suppose an entire hostel of 1000 students gets tested for Covid and someone has a positive result. The test detects 90% of Covid cases correctly. What is the probability of the person who tested positive having Covid?
  - Probability of Covid in general population is 1% (assume)
  - Probability of positive test if one has Covid = 90% (10% false negative)
  - Probability of negative test if one doesn't have Covid = 90% (10% false positive)
  - Probability of Covid given a positive result has been obtained = 9/108 = around 8%, not same as probability of positive result given one has Covid (90%)

Total = 1000	Disease (10)	No disease (990)	Total +ve/-ve tests
Positive result	9	99	108
Negative result	1	891	892

Fallacious reasoning: summary

- How to spot fallacious reasoning?
  - Given an argument, clearly list the premises and conclusions, even if unstated
  - Check if all premises are justified and all relevant premises are considered
  - Check if the conclusion logically follows from the premises
  - Watch out for common fallacies in premises and inference methodology
- Does cogent reasoning always lead to the "right" answer?
  - Mostly, but not always, e.g., corner case missed in inductive argument, but turns out to be true in real life
  - Will it lead to logical decision making and clarity of thought? Yes
  - Will it make you happy always? No guarantees!

Summary: Scientific thinking in daily life

- Apply cogent reasoning to arguments in daily life
  - Ascertain truth of premises independently, with skepticism
  - Consider all sides of argument objectively, without bias
  - Use valid ways of drawing conclusions, avoid common pitfalls
  - Interpret statistics and probability correctly
  - Accept differences in background beliefs respectfully
- Engage with scientific/political/other debates with correct reasoning, make logical decisions in work and life, think clearly and act
- "The unexamined life is not worth living". -Socrates