Introduction to Human Sciences

02. Logic and Critical Thinking

What is Logic?

- The **study of rational argumentation**

- **Purpose**:
  - distinguishing good arguments from bad arguments

- A **'normative' discipline** (vs. descriptive)
  - Is vs. ought

- The **art of self-defense**
  - Against bad arguments, rhetoric, non-reasonable ways of persuation and propaganda
  - For supporting conclusions with well-grounded premises
  - For building arguments that withstand scrutiny
  - For clarity and effective writing

Inferences all the time...

- **See them in earphones**
  - Infer they must be listening to music
- **hear them speaking in good Hindi**
  - infer that they must be from the north
- **See the two together**
  - Infer they must be a couple
- **See a bearded guy wearing a kurta and carrying a jhola**
  - Infer he must be from JNU
- **Know she's pursuing her engineering from IIT**
  - Infer she wrote JEE
- **Know he's a billionaire**
  - Infer he's a happy man

Logic: Formal and Informal

- **Formal logic**
  - Has to do with the '**form' or 'structure**' of arguments
  - **Consists of**
    - Categorical propositions
    - Syllogisms
    - Propositional logic
    - Truth tables
    - Predicate logic
- **Informal logic**
  - Has to do with the **'content' or 'meaning'** of premises in argument
  - More to do with **identifying the fallacies in everyday reasoning**
  - Forms a major part of **critical thinking**

Articulating disagreement

- **COPPLESTON**: As we are going to discuss the existence of God, it might perhaps be as well to come to some provisional agreement as to what we understand by the term "God."I presume that **we mean a supreme personal Being—distinct from the world and Creator of the world.** Would you agree—provisionally at least—to accept this statement as the meaning of the term "God"?

- **RUSSELL**: Yes, I accept this definition.

- **COPPLESTON**: Well, my position is the **affirmative position that such a Being actually exists, and that His existence can be proved philosophically.** Perhaps you would tell me if your position is that of agnosticism or of atheism. I mean, **would you say that the non-existence of God can be proved?**

- **RUSSELL**: No, I should not say that: **my position is agnostic.'**

What is an argument?

- A good argument
  - One in which **the premises give us a "good" reason to believe in the conclusion**

- Building blocks of an argument
  - **Premises, conclusion, inference**
    - Floor = premises
    - Roof = conclusion
    - Cement = inference
  - **Foundation?**
    - Laws of logic!

Sentence vs. Proposition

- **Propositions/statements**
  - **Building blocks** of reasoning
  - **Assert** something is (or is not) the case
  - Have a **truth-value**: Either true or false
  - The **meaning expressed by sentences**
- **Sentences**
  - **Two sentences** can express the **same proposition**
  - **Across languages**
    - "It is morning"
      - Podduna ayindi
      - Kalai aache
      - Subah ho gayi
  - **Across descriptions**
    - **A is to the right of B**
      - B is to the left of A

Truth vs. Validity

- **Validity** is a **property of arguments**
  - Arguments are valid or invalid
  - Arguments CANNOT be said to be true or false
- **Truth** is a **property of premises** (the propositions) making up the argument
  - **Premises are true or false**

Example

- **All women are mortal**
  - Socrates is a woman
    - Therefore, Socrates is mortal
- This is a **VALID argument** (due to its very **'form')**
  - BUT the **second premise is a false one**!
  - Therefore, the argument is **deductively valid but not 'SOUND'!**
- All men are mortal
  - Socrates is a man
    - Therefore, Socrates is mortal
- This is a **VALID argument**, and since **all the premises are true**, it is also a **SOUND argument**
- **What about this?**
  - All bankers are rich; Tom is rich; therefore, Tom is a banker.
  -

Types of Inferences: Deductive

- Conclusion is supported by its premises **conclusively**
  - **If the premises is true**, the **conclusion HAS TO BE true**!
  - A **good deductive argument** is **truth-preserving (when valid**)
    - an argument is truth-preserving iff
      - **it is not logically possible for its premises to be true whilst its conclusion is false**
- IN ORDER TO UNDERSTAND THIS, WE MUST DISTINGUISH
  - **LOGICAL VS. PHYSICAL IMPOSSIBILITY**

EXAMPLE OF A TRUTH-PRESERVING ARGUMENT

- All heavenly bodies revolve around the earth.
  - The sun is a heavenly body
  - Therefore the sun revolves around the earth
- Yet its conclusion is false, as is at least one of its premises

Laws of Thought

- **The law of noncontradiction: (Cannot be both A and not-A)**

  – Nothing can both have a property and lack it at the same time.

- **The law of identity: (A = A)**

  – Everything is identical to itself.

- **The law of excluded middle: (Either A or not-A)**

  – For any particular property, everything either has it or lacks it.

Consider this!

- "Without the law of noncontradiction, we can't believe things to be one way rather than another. But if we can't believe things to be one way rather than another, we can't think at all."

  – *Reductio ad absurdum!*

Logical vs. Physical Impossibility

- **PHYSICAL IMPOSSIBILITY**
  - IF SOMETHING IS **INCONSISTENT WITH THE LAWS OF NATURE**
  - **SCIENCE** TELLS US WHAT IS PHYSICALLY IMPOSSIBLE
- **LOGICAL IMPOSSIBILITY**
  - IF SOMETHING IS **INCONSISTENT WITH THE LAWS OF LOGIC**
    - MARRIED BACHELOR
    - SQUARE CIRCLE
    - SOMETHING TO BE RED AND NOT-RED
    - ALL "OXYMORONS" ARE LOGICAL IMPOSSIBILITIES
      - LESS IS MORE
      - SAME DIFFERENCE
      -

- LOGICAL POSSIBILITY BUT PHYSICAL IMPOSSIBILITY
  - ARCHIMEDES:
    - "Give me a lever long enough and a fulcrum on which to place it, and I shall move the world"!!

Types of Inferences: Inductive

- **NOT TRUTH-PRESERVING**
  - THEIR BEING GOOD IS A **MATTER OF DEGREE**
  - CAN DETERMINE ONLY "**A POSTERIORI**"
  - **EMPIRICAL INVESTIGATIONS** ARE UNDERTAKEN
- **STRENGTH/GOODNESS OF INDUCTIVE ARGUMENTS**
  - INDUCTIVE ARGUMENTS ARE **EITHER WEAK OR STRONG**
  - **VALIDITY/INVALIDITY DOES NOT APPLY** TO INDUCTIVE ARGUMENTS
- **EMPIRICAL SCIENCE** AS INVOLVED IN APPRAISING INDUCTIVE ARGUMENTS
  - INDUCTIVE ARGUMENTS MAY BE BETTER, WORSE, WEAKER, STRONGER, ETC.
- **NOTE:**
  - IN THE WORLD OF INDUCTIVE ARGUMENT—EVEN WHEN THE CONCLUSION IS JUDGED TO BE VERY HIGHLY PROBABLE—**ALL THE EVIDENCE IS NEVER IN**.
  - **NEW DISCOVERIES MAY EVENTUALLY DISCONFIRM** WHAT WAS EARLIER BELIEVED, AND THEREFORE WE **NEVER ASSERT THAT THE CONCLUSION OF AN INDUCTIVE ARGUMENT IS ABSOLUTELY CERTAIN**.
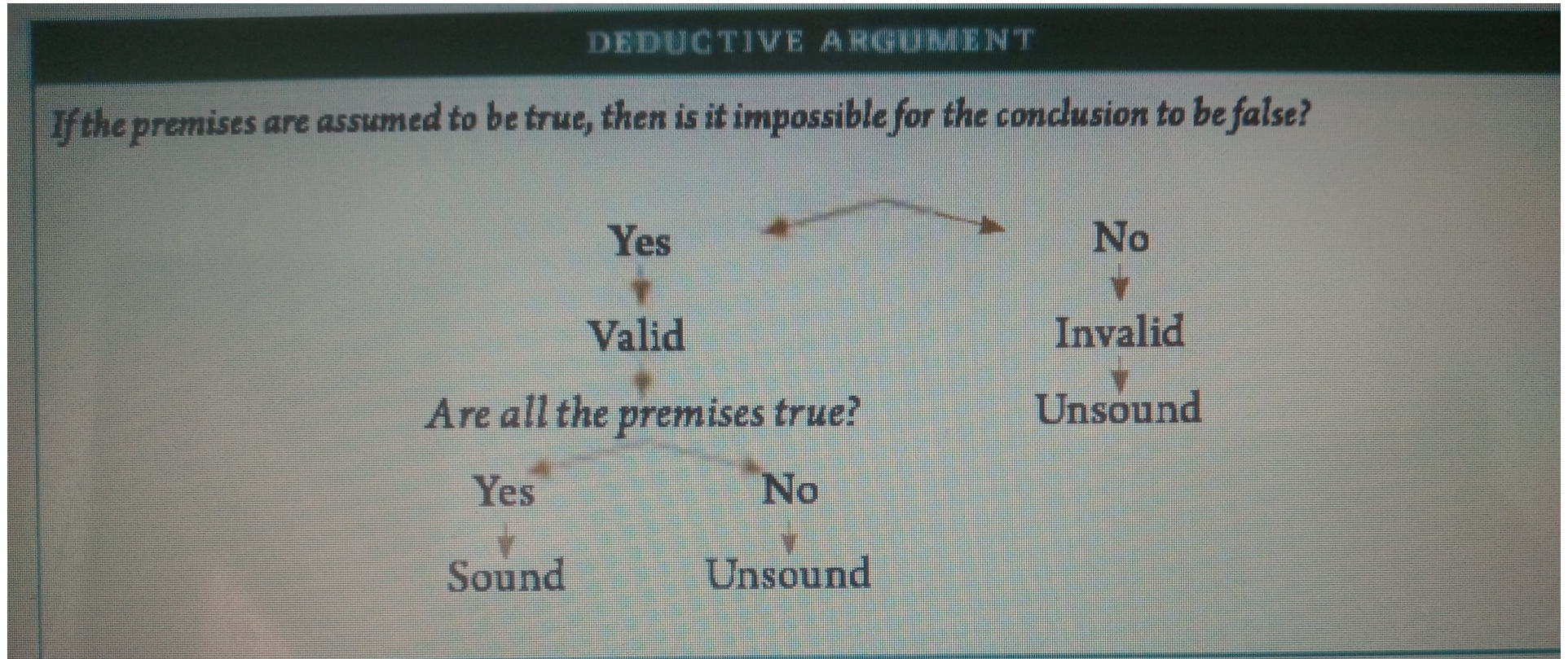
John Searle's
Chinese Room Argument

- **Axiom 1**: Computer programs are formal (syntactic); **Church-Turing thesis**

- **Axiom 2**: Human minds have mental contents (semantics)

- **Axiom 3**: Syntax by itself is neither constitutive of nor sufficient for semantics

  - **Conclusion 1**: Programs are neither constitutive of nor sufficient for minds

- **Axiom 4**: Brains cause minds

  - **Conclusion 2**: Any other system capable of causing minds would have to have causal powers (at least) equivalent to those of brains

  - **Conclusion 3**: Any artefact that produced mental phenomena, any artificial brain, **would have to be able to duplicate the specific causal powers of brains**, **and it could not do that just by running a formal program**

  - **Conclusion 4**: The way that human brains actually produce mental phenomena cannot be solely by virtue of running a computer program.

Evaluating arguments

- Tom is a banker. All bankers are rich. Therefore Tom is rich.

- Sue and Tom lead similar lives but Sue smokes and Tom doesn't. Therefore Sue is more likely to die from heart disease than Tom.

- This taxis respects women. My friend respects women. Therefore, my friend is a taxi.

- Killing is wrong. Therapeutic cloning involves killing. Therefore therapeutic cloning is wrong.

- Every person with Huntington's Disease who has been examined, has had the HD gene on chromosome 4. Therefore everyone with HD has the HD gene on chromosome 4.

- If this liquid is acidic it will turn litmus paper blue. This liquid does not turn litmus paper blue. Therefore this liquid is not acidic.

Flowchart: Deductive Argument

DEDUCTIVE ARGUMENT

If the premises are assumed to be true, then is it impossible for the conclusion to be false?

Yes   →   No

Valid   Invalid

Are all the premises true?   Unsound

Yes   No

Sound   Unsound

Evaluating arguments: Continued

- Those who are not on social media are anti-progress, since those who are not on social media are anti-technology, and those who are anti-technology are anti-progress.

- each time a black cat crossed my path, i got stuck in a traffic jam; a black cat crossed my path this morning, therefore, i will be stuck in a traffic jam

- green tea contributes to fat loss; i will become thin if i drink green tea

- exercise greatly reduces the risk of type 2 diabetes; i exercise regularly; the chances of me getting type 2 diabetes is low

Evaluating arguments: Continued

- All mammals have lungs. All whales are mammals. Therefore all whales have lungs.

- All four-legged creatures have wings. All spiders have exactly four legs. Therefore all spiders have wings.

- If I owned all the gold in Fort Knox, then I would be wealthy. I do not own all the gold in Fort Knox. Therefore I am not wealthy.

- If Bill Gates owned all the gold in Fort Knox, then Bill Gates would be wealthy. Bill Gates does not own all the gold in Fort Knox. Therefore Bill Gates is not wealthy.

  – How is this different from the above?

- All fishes are mammals. All whales are fishes. Therefore all whales are mammals.

- All mammals have wings. All whales have wings. Therefore all whales are mammals.

- All mammals have wings. All whales have wings. Therefore all mammals are whales.

- The earth revolves around the sun. Thursday follows wednesday. Hyderabad is the capital of Telangana

Fallacies of deductive inference: 1

- **Modus ponens (valid form)**
  - If A, then B;
    - A; therefore, B
  - Antecedent: that which comes after 'if' (A)
  - Consequent: that which comes after 'then' (B)
  - The **valid form** of modus ponens involves *affirming the antecedent*, i.e., A is affirmed in the second premise
- **Fallacious form**
  - If A, then B;
    - not A; therefore not B
  - The fallacy of *denying the antecedent*

Fallacies of deductive inference: 2

- **Modus tollens (valid form)**
  - If A, then B;
    - Not-B; therefore, not-A
  - **Antecedent**: that which comes after if (A)
  - **Consequent**: that which comes after then (B)
  - The valid form of modus ponens involves *denying the consequent*, i.e., B is denied in the second premise
- **Fallacious form**
  - If A, then B;
    - B; therefore A
  - The fallacy of *affirming the consequent*

Necessary and Sufficient Conditions: If A, then B

- **Necessary conditions**
  - **Minimum requirements**
    - A is minimum requirement for B
  - That without which the effect cannot come about
    - Oxygen is necessary for combustion
    - Fuel is necessary for engine to run
    - Battery is necessary for your phone
- **Sufficient conditions**
  - That which **guarantees** the occurrence of the effect
    - A is sufficient for B; A guarantees B
  - If there's A, then B follows
    - Combustion is sufficient to prove the presence of oxygen
    - That my phone is ringing is sufficient condition for there being charge in it.
- So in a conditional statement,
  - the **antecedent is a sufficient condition for the consequent**
  - and the **consequent is a necessary condition for the antecedent.**

Conditional Fallacies

- If there's oxygen, then there's fire
  - there's no fire; therefore there's no oxygen
- If there's oxygen, then there's fire
  - there's oxygen; therefore there's fire
  - --------------------compare with-----------------------------------
- If there's fire, then there's oxygen
  - there's fire; therefore there's oxygen
- If there's fire, then there's oxygen
  - there's no oxygen; therefore there's no fire

When Evaluating Conditional Fallacies

- Make sure that:
  - The antecedent is the sufficient condition for the consequent
  - The consequent is the necessary condition for the antecedent
    - Fire is a sufficient condition for presence of Oxygen
    - Presence of Oxygen is a necessary condition for there to be fire.

Everyday examples

- To hold a guitar is a necessary condition to be a guitarist; alas! it's not sufficient, unfortunately

- HIIT is a sufficient condition to lose weight; but losing weight does not imply one is doing HIIT; i.e., it is not a necessary condition

- If my motorcycle is running, then there is fuel in the tank

- If there is water in the tank, then there is water in the shower

- If there is wifi, then there is internet

- In sum, the distinction between induction and deduction rests on the **nature of the claims** made by the two types of arguments about the relations between their premises and their conclusions. Thus we characterize the two types of arguments as follows:

    - A deductive argument is one whose conclusion is claimed to follow from its premises with **absolute necessity**, this necessity not being a matter of degree and not depending in any way on whatever else may be the case.

    - In sharp contrast, an inductive argument is one whose conclusion is claimed to follow from its premises **only with probability**, this probability being a **matter of degree** and dependent on what else may be the case.

Read:

- Read Copi and Cohen, *Introduction to Logic,* Chapter 1, "Basic logical concepts"

- Chapter 2, (pp. 16-22) "Logical possibility versus physical impossibility" from Schick and Vaughn, *How to Think about Weird Things: Critical Thinking for a New Age*.

- Watch:
  - BBC, The Joy of Logic