METHODS

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Overview

- Chapter 1: Thinking like a scientist
  - Criteria of science
  - Thinking like a scientist
  - Deduction and induction (not really in "the book", but part of exam)

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Criteria of Science

- First of all, **method** determines science, not subject matter.
- Systematic empiricism:
  - Simply observing does not lead to scientific knowledge.
  - Observation must be done in a structured and systematic way.
    - Role of Methodology.
- Public Verification:
  - Presenting research to the public so that it can be observed, replicated, criticized, and tested.
  - Examples: Publication in journals, books, conference proceedings, presenting papers at conferences, seminars, workshops, etc.
  - Purpose: To determine the **veracity** of a theory.

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Criteria of Science

- Systematic empiricism
- Public verification
- **Empirically solvable problems.**
  - Questions that are potentially answerable by means of currently available research techniques.
  - Principle of falsifiability: stating a scientific theory in such a way that it is possible to refute or disconfirm it.
  - Compare: Pseudoscience
  - Purpose: to determine whether a theory can potentially be tested using empirical techniques and whether it is falsifiable.

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Science versus Pseudoscience

- Principle of falsifiability distinguishes science from pseudoscience.
- Pseudoscience: a claim that appears to be scientific but that actually violates the criteria of science.
- Examples:
  - Astrology;
  - Homeopathy.
- Example: Extrasensory Perception (ESP): proponents claim that ESP does not work in controlled environments.
  - If "demonstrated" → claim that it works.
  - If not → claim that it does not work under controlled circumstances. I.e. falsifying data are never valid.
  - If no **principled way of falsifying** existence of ESP, it cannot be a scientific claim.

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What kinds of claims are Testable/Non-Testable?

- Testable = can be verified and can be falsified.
- Non-testable statements:
  - Speculative statements.
  - Normative statements.
  - Definitions
  - Statements referring to unclear place or time.

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Testable or not?

1. Ghosts exist.
2. One ought to eat with knife and fork.
3. A family is a social group consisting of parents and their children.
4. In 2010, the inhabitants of some European countries voted relatively more frequently for right wing parties.
5. People have a preference to marry a partner with an equal level of education.
6. A cow is an animal with four legs.

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Thinking like a scientist

- Skeptic: "A person who questions the validity, authenticity, or truth of something purporting to be factual."
- Skeptics accept claims only after examining and evaluating the evidence supporting the claim.
- Skeptics have an open mind, but are not gullible:
  - "Keeping an open mind is a virtue, but not so open that your brains fall out". (Bertrand Russel).
- Balance between 'being open minded' and demanding that the evidence satisfies scientific criteria:

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Thinking like a scientist

- "It seems to me what is called for is an exquisite balance between two conflicting needs: the most skeptical scrutiny of all hypotheses that are served op to us and at the same time a great openness to new ideas. If you […] have not an ounce of skeptical sense in you, then you cannot distinguish useful ideas from the worthless ones. If all ideas have equal validity, then you are lost, because then […] no ideas have any validity at all." (Carl Sagan).

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Thinking like a scientist

- Skeptics are able to say: 'I don't know'.
- Believing a claim is not a dichotomy (yes versus no) but a continuum: a scale ranging from strong disbelief to strong belief in the claim.
- 'I don't know' is right in the middle of the scale, and should be the starting point in evaluating the evidence.

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Thinking like a scientist

- Thomas Kida (2006, p. 53): Evaluating a claim.

1. Formulate the claim.
2. Evaluate the evidence for the claim.
3. Consider alternative explanations (hypotheses).
4. Evaluate the reasonableness of each of these explanations (hypotheses).

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Evaluating a claim

1. Formulate the claim.
   - The claim must be stated in clear and specific terms.
   - Science: the claim must be potentially falsifiable.
2. Evaluate the evidence.
   - Not all evidence is equal. For example, the quality of personal narratives (anecdotal evidence) is less than that of evidence from a study under controlled circumstances.
   - Obviously, scientists make mistakes as well. (But a course in Research Methods helps you detect and prevent them).

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Evaluating a claim

3. Consider alternative explanations.
   - Evaluate the reasonableness of these explanations:
   - Is the explanation testable?
   - Is it the simplest explanation available? (Occam's razor)
4. Does the explanation conflict with other well-founded knowledge?

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BAARN - Older women may lower their risk at developing several types of cancer by regularly drinking green tea. That is the result of a study among thousands of Chinese women.

The researchers used the data from a long-term study involving more than 69.000 Chinese women of 50 years and older. More than 19.000 participants were seen as persons who regularly drink tea. During a period of 11 years, 1255 women developed throat, stomach, or colon cancer. Women who reported that they drank a lot of green tea the last 20 years, had a decreased risk of about 27 percent of developing these types of cancer.

Women who drank green tea at least three times a week, lowered their risk at tumors in the gastric system by 14 percent.

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No evidence

The protective effect of green tea may be due to the antioxidants it contains, but this has not been demonstrated sufficiently. Green tea drinkers were not only younger, but also exercised more and ate more fruit and vegetables. The researchers tried to rule out these factors, but they admit that that will never be completely successful.

The results of the study have been published in the American Journal of Clinical Nutrition.

Source: http://www.nu.nl/gezondheid/2948899/groene-thee-verlaagt-risico-keel--maag--en-darmkanker.html

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Evaluating the claim

1. State the claim
   - Antioxidants in green tea help to prevent cancer. (This is a causal claim).
2. Study the evidence (what is the reason to believe the claim?)
   - An epidemiological study involving 69.000 women shows that:
   - Women reporting to have drunk a lot of green tea the last 20 years had a considerable lower risk at developing three types of cancer.
   - Women reporting to drink green tea at least three times a week had a lower risk at devolping cancer in the gastric system.
3. Consider alternative explanations
   - The women were also younger, exercised more regularly and ate more fruits and vegetables.
4. Evaluate the reasonableness of these explanations.

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Foundations of Science

- Science combines empiricism and rationalism.
  - Logical reasoning in combination with empirical observation.
- Two forms of reasoning:
  - Deduction
  - Induction

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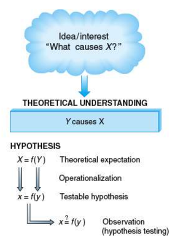
Deduction in science



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Example deduction

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- Major premise: differences in upbringing influence communication behavior.
- Premise 1: The upbringing of men and women differs.
- Premise 2: interrupting a conversation is a form of communication behavior.
- Conclusion: Men and women differ in their interruptions.

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Deduction versus Induction

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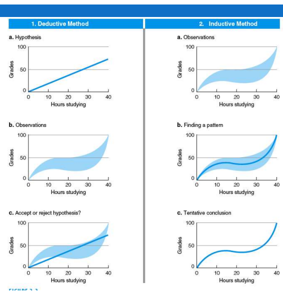

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Empirical Cycle

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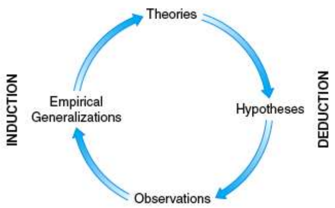

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Ordinary Human Inquiry: Reasoning

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- There are four cards on the table that show: A, B, 2, 3
- Each card has a letter on one side and a number on the other.
- Your task is to assess the truth of the following rule:
- If a card has a vowel on one side, the number on the other side is even.
- Which card(s) will you turn to check the rule?

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Ordinary Human Inquire: Reasoning

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- Imagine that you are a police officer for making sure that the drinking age rule is being followed. The rule is: "If a person is drinking alcohol, then the person is 21 years or older."
- There are four cards with information. Each card has a drink on the one side, and the age of a person drinking it on the other.
- The cards are:
- Beer.
- Coke.
- 22 years old.
- 16 years old.
- Which card(s) are you going to turn to check the rule?

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Logically speaking:

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A	B	A → B
True	True	True
True	False	False
False	True	True
False	False	True

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Deduction

- Main characteristics:
  - Validity The reasoning is valid if true premises necessarily lead to true conclusions.
  - Soundness: the reasoning is sound if it is not only valid, but premises are true as well.

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Deduction

- All birds have feathers.
- All chickens are birds.
- So, all chickens have feathers.

- Valid?
- Yes, assuming the premises are true, the conclusion must be true.

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Deduction

- All birds can fly.
- All chickens are birds.
- So, all chickens can fly.

- Valid?
- Yes.

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Deduction

- All birds can fly.
- All bats can fly.
- So, all bats are birds.

- Valid?
- No, since even if the premises are true that does not make the conclusion necessarily true.

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Deduction

- Modus Ponens:
  - If an animal is a bird, it can fly. (If A, then B)
  - This animal is a bird. (A)
  - So, this animal can fly. (B)

- Modus Tollens:
  - If an animal is a bird, it can fly (If A, then B)
  - This animal cannot fly. (-B)
  - Therefore, this animal is not a bird. (-A)

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Deduction: Invalid

- If an animal is a bird, it can fly. (If A, then B)
- This animal can fly. (B)
- Therefore, it is a bird. (A)

- If an animal is a bird, it can fly (If A, then B)
- This animal is not a bird. (-A)
- Therefore, this animal cannot fly. (-B)

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Deduction: Soundness

- All birds can fly.
- All penguins are birds.
- So, all penguins can fly.

- Valid? Yes.
- Sound? No.
- The reasoning is unsound because the premises are untrue. (= at least one of the premises is untrue).
- If the conclusion is untrue and the reasoning is valid, then I know for a fact that the premises must be untrue.

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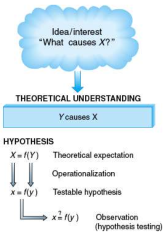
Deduction in science



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Logical Reasoning

- If my hypothesis is true, I will observe result R. (If A then B)
- I observed result R. (B)
- Therefore my hypothesis is true. (A)

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Logical Reasoning

- If my hypothesis is true, I will observe result R. (If A then B)
- I do not observe result R. (- B)
- Therefore my hypothesis is untrue. (-A)

- First year students are worse at arithmetic than second year students.
- If that is true, first year students will score lower on the arithmetic test than second year students.
- All students have the maximum score on the arithmetic test, so first year students do not score lower.
- Therefore, it is not true that first year students are worse at arithmetic than second year students.

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Arithmetic Test

- Answer the following questions:
- 1 + 1 =
- 1 + 2 =
- 1 + 3 =

- What does this teach us?
- We'll have to assume that the test is capable of showing differences in arithmetic skills.
- Construct validity (see next week).
- This assumption is also called an **auxiliary hypothesis.**
- If the auxiliary hypothesis is false, the reasoning becomes unsound (since the premises are false).
- But even if all premises are true the conclusion that there is no difference in arithmetic skills is based on invalid reasoning (see next slide).

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Logical Reasoning

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Valid

- If my hypothesis is true, and my auxiliary hypothesis is true, I will observe result R. (If A and B then C)
- I do not observe result R. (-C)
- Therefore, my hypothesis or my auxiliary hypothesis is untrue (or both). (-A or -B)

Invalid

- If my hypothesis is true, and my auxiliary hypothesis is true, I will observe result R. (If A and B then C)
- I did observe result R. (C)
- Therefore my hypothesis is true and my auxiliary hypotheses is true (A and B)

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In any study:

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- Substantive hypothesis coupled with many auxiliary hypotheses.
- Verification of prediction does not lead to the valid conclusion that substantive hypothesis is correct.
- An experiment cannot proof a theory right!
- Falsification of prediction **does not lead to the valid conclusion** that my substantive hypothesis is incorrect. (Only that at least one of my assumptions is incorrect).
- However, verification may make the substantive hypothesis more plausible and falsification may make the substantive hypothesis less plausible.
- This brings us to induction.

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Logical Reasoning: Induction

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- Inductive reasoning cannot lead to logically valid conclusion (only deduction can).
- The conclusion of an induction is not necessarily true, but induction may lead to a plausible (likely) conclusion.
- John likes tennis, basketball, football, and chess. So, John likes sports.
- The sun has come up everyday, so it will likely go up tomorrow.

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Induction

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- Inductive reasoning is **strong** if the premises make the conclusion plausible (and **weak** if is does not).
- Inductive reasoning is **cogent** if it is strong and its premises are true.

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Induction

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- If my hypothesis is true and all my auxiliary hypothesis are as well, I will probably observe results R.
- I observe R.
- So, my hypothesis is probably true. (assuming my auxiliary hypotheses are true).
- **Skeptical attitude/ critical thinking:**
- Is it true that result R will occur with high probability?
- We can use statistics to figure that out.
- Are all auxiliary hypotheses true or at least reasonable? (Think about the test that was too easy).
- These are questions we can answer with the rules, norms, and guidelines of methodology.

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Deduction and Induction

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- Deduction:
  - Valid: given the premises the conclusion is necessarily true.
  - Sound: the reasoning is valid and the premises are true.
- Induction:
  - Strong: the conclusion is plausible (likely) given the premises.
  - Cogent: the reasoning is strong and the premises are true.

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