



Cognitive Biases

CS4246/CS5446

AI Planning and Decision Making

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Cognitive Biases and Psychological Traps

- Our minds sometimes play tricks on us.
- These traps are hardwired into our thinking process
 - We fail to recognize them, even when falling right into them
- By being aware of them, we can learn to understand and compensate for them.



List of Cognitive Biases

- Biases Emanating from the Availability Heuristic
 - 1. Ease of recall
 - 2. Retrievability
 - 3. Presumed associations
- Biases Emanating from the Representativeness Heuristic
 - 4. Insensitivity to base rates
 - 5. Insensitivity to sample size
 - 6. Misconceptions of chance
 - 7. Regression to the mean
 - 8. The conjunction fallacy
- Biases Emanating from Anchoring and Availability
 - 9. Insufficient anchor adjustment
 - 10. Conjunctive and disjunctive events bias
 - 11. Overconfidence
- Two More General Biases
 - 12. The confirmation trap
 - 13. Hindsight and the curse of knowledge



Bias 1: Ease of Recall

- Based upon vividness and recency
- An event whose instances are more easily recalled will appear more numerous than an event of equal frequency whose instances are less easily recalled.



Examples

- Problem 1: The following 10 corporations were ranked by a business magazine to be among the 500 largest United States-based firms according to sales volume for 2020; which group has the larger sales volume?
 - a. Google, Apple, Facebook, Amazon, Citibank, Nike, AIA, United Airlines, Pfizer, Moderna
 - b. Walmart, Amazon, Exxon Mobil, Apple, CVS Health, Berkshire Hathaway, UnitedHealth Group, McKesson, AT&T, AmerisourceBergen**



Bias 2: Retrievability

- Based upon memory structures
- Organization structures or modes may affect search



Examples

- Problem 2a: In four pages of a novel (about 2000 words), how many words would you expect to find that have the form ing?
 - a. 0-5
 - b. 6-15
 - c. 16+
- Problem 2b: In four pages of a novel (about 2000 words), how many words would you expect to find that have the form n ?
 - a. 0-5
 - b. 6-15
 - c. 16+
- Problem 2c: In general, you would expect the answer to 2a and the answer to 2b:
 - a. $\text{Ans } 2a \geq \text{Ans } 2b$
 - b. **$\text{Ans } 2a \leq \text{Ans } 2b$**
 - c. To be exactly the same number
- Strategic locations of retail stores or goods in a supermarket or retail stores
 - Easier for customers to learn the “location” for a particular type of product or store and organize their minds accordingly



Bias 3: Presumed Associations

- Bias in assessing the likelihood of two events occurring together.
- When the probability of two events co-occurring is judged by the availability or perceived co-occurring instances in our minds, we usually assign an inappropriately high probability that the two events will co-occur again



Examples

- Consider:
 - Problem 3a: Is drug-use related to delinquency?
 - a. Yes
 - b. No
 - c. **Unsure**
 - Problem 3b: Are couples who get married under the age of 25 more likely to have bigger families?
 - a. Yes
 - b. No
 - c. **Unsure**
- There are actually always at least four separate situations to be considered in assessing the association between two dichotomous events



Bias 4: Insensitivity to Base Rates

- Frequently occur when the wrong cognitive question is asked -- reversal of the context and the phenomenon



Examples

- Problem 4a: The best student in a Master of Business Administration (MBA) class writes poetry is rather shy and small in stature. Which is more likely to be the student's undergraduate major?
 - a. Music and Literature
 - b. **Computer Science**
- How likely is it that someone like this student would take Music and Literature? vs
- How likely is it that someone who takes Music and Literature would fit the student's description?
- Problem 4b: Mark is finishing his MBA at a prestigious university. He is very interested in the arts and at one time considered a career as a musician. Is Mark more likely to take a job
 - a. in the management of the arts?
 - b. **with an Internet start-up?**



Bias 5: Insensitivity to Sample Size

- While sample size is a fundamental concept in statistics, it is rarely a part of our intuitions
- People tend to use the representativeness heuristic when responding to problems dealing with sampling



Example

- Problem 5: A town is served by two hospitals.
- In the larger hospital about 60 babies are born each day and in the smaller hospital about 20 babies are born each day. About 50% of all babies are boys. However, the exact percentage varies from day to day.
- For a period of one year, each hospital recorded the days in which more than 60% of the babies born were boys. Which hospital do you think recorded more such days?
 - a. The larger hospital
 - b. The smaller hospital**
 - c. About the same (within 5% of each other)



Bias 6: Misconceptions of Chance

- Individuals expect
 - probabilities to even out;
 - a series of events to be highly correlated; and
 - the “law of small numbers” -- sample events are far more representative of the population from which they were drawn than simple statistics would dictate



Examples

- Problem 6a: You are about to buy another “pre-loved” laptop. You predict that the next laptop should work fine, since the last four were “lemons” (bad products), and the odds favor getting at least a good one in five tries. This thinking is:
 - a. correct.
 - b. incorrect.**
- Problem 6b: Rank the likelihoods of occurrence of the following three sequences of coin flips:
 - I. H-T-H-T-T-H
 - II. H-H-H-T-T-T
 - III. H-H-H-H-T-H
 - a. I, II, III
 - b. II, I, III
 - c. III, II, I
 - d. III, I, II
 - e. They are equally likely**
- Problem 6c: Do you believe in the “hot-hand” in basketball?
 - Research results based on small sample sizes



Bias 7: Regression to the Mean

- Individuals expect future outcomes will be maximally representative of past outcomes
- Individuals tend to naively develop predictions that are based upon the assumption of perfect correlation with past data
- We tend not to recognize the regression effect in less extreme cases
- Misconception on regression would lead to:
 - Overestimation of effectiveness of punishment
 - Underestimation of power of reward



Examples

- Problem 7: Sales projection. Given the data for 9 retail stores in 2020 totaling \$90,000,000, and projected total for 2021 totaling \$99,000,000. How should you project the 2021 sales data for each retail store? (Disregarding impact of pandemic)
 - a. Add 10% to the sales in 2019 for each retail store
 - b. Estimate \$11,000,000 for each retail store
 - c. **Estimate a number between \$11,000,000 and 110% of the sales in 2019 for each retail store, totaling to \$99,000,000**
 - d. None of the above



Bias 8: The Conjunction Fallacy

- Conjunction judged more probable than a single component descriptor when the conjunction appears more representative or more available
- Would lead to irrational conclusions in medical judgments, sporting events, criminal behavior, international relations



Example

- Problem 8: Linda is 31 years old, single, outspoken, and very bright. She majored in political science. As a student, she was deeply concerned with issues of discrimination and social justice, and she participated in climate change demonstrations. Rank the following descriptions in terms of the probability that they describe Linda:
 - I. Linda is active in the feminist movement
 - II. Linda is a bank teller
 - III. Linda is a bank teller who is active in the feminist movement
- a. III, I, II
- b. II, III, I
- c. I, III, II
- d. **None of the above**



Bias 9: Insufficient Anchor Adjustment

- Adjustments away from anchors are usually not sufficient to negate the effects of the anchor
- Answers are biased toward the initial anchor, even if it is irrelevant
- Different starting points yield different answers



Examples

- Problem 9: A piece of paper is folded in half. It is folded in half again, and again, ... After 100 folds, do you think the thickness will be:
 - a. Less than 1 meter
 - b. Between 1 to 10 meters
 - c. **More than 100 meters?**



Bias 10: Conjunctive and Disjunctive Events Bias

- Overestimate probability of conjunctive events and underestimate probability of disjunctive events
- Probability of any event occurring provides a natural anchor for the judgment of the total probability



Example

- Problem 10: Which of the following appears most likely?
 - a. Drawing a red marble from a bag containing 50% red marbles and 50% white marbles 50%
 - b. Drawing a red marble seven times in succession, with replacement, from a bag containing 90% red marbles and 10% white marbles 48%
 - c. **Drawing at least one red marble in seven tries, with replacement, from a bag containing 10% red marbles and 90% white marbles** 52%



Bias 11: Overconfidence

- Overconfident in estimation abilities and do not acknowledge the actual uncertainties that exist
- When individuals are asked to set a confidence range around an answer, the initial estimate serves as an anchor which biases the estimation of confidence intervals in both directions
- Overconfidence tends to increase when knowledge decreases
- People are overconfident even when virtually certain they are correct
- Overconfidence is not simply a consequence of taking the task lightly or misunderstanding how to make confidence ratings
- Overconfidence increases with incentives to perform well
- To reduce overconfidence:
 - Give feedback about overconfidence based on judgments
 - Ask people to explain why their answers might be wrong



Examples

- Problem 11: Listed below are 10 uncertain quantities. For each, write down your best estimate of the quantity. Next, put a lower and upper bound around your estimate, such that you are 90% confident that your range surrounds the actual quantity.

- | | | |
|-----|--|----------------------|
| 1. | The world population in 2020 | <i>7,800,000,000</i> |
| 2. | Rice exported (in metric tons) by Thailand in 2020 | <i>7,500,000</i> |
| 3. | Length of the Nile River in km | <i>6,650km</i> |
| 4. | Number of countries that are members of ASEAN | <i>10</i> |
| 5. | Diameter of the moon in km | <i>3,474.8km</i> |
| 6. | Weight of an empty Boeing 787 in kg | <i>110,000 kg</i> |
| 7. | Year in which Wolfgang Amadeus Mozart was born | <i>1756</i> |
| 8. | Gestation period (in months) of an Asian elephant | <i>18-22 months</i> |
| 9. | Air distance from London to Tokyo in km | <i>9,559.36 km</i> |
| 10. | Deepest known point in the ocean in m | <i>11,035 m</i> |

- How many of your 10 ranges actually surround the true quantities?



Bias 12: The Confirmation Trap

- People usually seek confirmatory evidence and exclude the search for disconfirming information from the decision processes
- Search for challenging, or disconfirming, evidence will actually provide the most useful insights

Example

- Problem 12: You heard that when this great analyst predicts a rise in the market, the market always rises. You are to check this claim. Examine the information available about the following four events (cards):

Card 1
(Prediction)
Favorable Report

Card 2
(Prediction)
Unfavorable Report

Card 3
(Outcome)
Market Rise

Card 4
(Outcome)
Market Fall

- You currently see the predictions (cards 1 and 2) or outcomes (cards 3 and 4) associated with the four events. You are seeing one side of a card. On the other side of cards 1 and 2 is the actual outcome, while on the other side of cards 3 and 4 is the prediction that the analyst made.
- Which cards would you turn over for the evidence that you need to check the analyst's claim?
 - Card 1 and Card 2
 - Card 1 and Card 3
 - Card 2 and Card 3
 - Card 1 and Card 4**



Bias 13: Hindsight and the Curse of Knowledge

- Hindsight:
 - Knowledge of an outcome increases the individual's belief about the degree to which he would have predicted that outcome without the benefit of that knowledge
- Common to use hindsight to criticize another's foresight judgment -- Reduce ability to learn from past and to evaluate decisions objectively
- Possible reasons:
 - Anchoring - interpret prior probability to anchor of known outcome
 - Availability - evidence associated with known outcome become more salient
 - Representativeness - Relevance of data judged by the extent to which it is representative of known outcome
- Curse of knowledge:
 - In predicting other's knowledge, people are unable to ignore knowledge that they have that others do not have



Examples

- Examples of the Hindsight bias:
 - Treatment decisions that turned out good or bad
 - Investment decisions that turned out good or bad
 - Various “I told you so!” scenarios
- Examples of the Curse of Knowledge bias:
 - Difficulty in teaching -- hard to imagine how much students know
 - Sophisticated hardware or software that nobody knows how to use
 - Highly technical talks given to the wrong audience



Homework

- Readings:
 - RN: 16.3.4 (Human judgment and irrationality)
- References on psychological traps and cognitive biases:

(Journal articles publicly available online or through NUS Library e-Resources)

 - Tversky, A. and D. Kahneman, [Judgment under Uncertainty: Heuristics and Biases](#). Science, 1974. 185(4157): p. 1124-1131
 - Kahneman, D. and A. Tversky, [Prospect Theory: An Analysis of Decision under Risk](#). Econometrica, 1979. 47(2): p. 263-291.
 - Hammond, J.S., R.L. Keeney, and H. Raiffa, [The hidden traps in decision making](#). Harvard Business Review, 1998. 76: p. 47+.
- General readings:
 - Hammond, J.S., R.L. Keeney, and H. Raiffa, Smart Choices: A Practical Guide to Making Better Decisions. 2015, Harvard Business Review Press.
 - Kahneman, D., Thinking, fast and slow. Thinking, fast and slow. 2011, New York, NY, US: Farrar, Straus and Giroux.
 - *Bazerman, M.H. and D.A. Moore, Judgment in Managerial Decision Making, 8th Edition. 2013: John Wiley & Sons.
 - * [Source of the examples](#).