PYB204 Perception & Cognition End of semester exam

Item 9: Reasoning and Decision Making

Reasoning and decision making

- When faced with logical problems, people often come to conclusions that are judged as incorrect from the perspective of formal logic and mathematics.
- On the other hand, computer systems that are based on formal logic make so many silly mistakes that humans never make.

Areas of reasoning and decision making

- Four areas where human irrationality is often found:
  - **Reasoning about conditionals**.
  - **Reasoning about quantifiers**.
  - **Reasoning about probabilities**.
  - **Decision making**.

Reasoning about conditionals

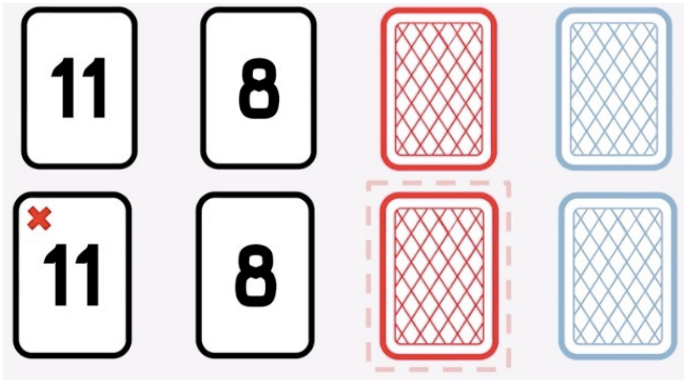
Deductive reasoning	Inductive reasoning
- Fred is the brother of Mary. - Mary is the mother of Lisa. ⇓ - Fred is the uncle of Lisa.	- Fred is the brother of Mary. - Mary is the mother of Lisa. ⇓ - Fred is older than Lisa.
Reasoning in situations where the conclusions can be determined to follow with certainty from the premises.	Reasoning in situations in which the conclusions follow only probabilistically from the premises.

Wason task and its variables

Conditional statement – if A, then B.

- An assertion that if an antecedent (A) is true, then a consequent (B) must be true.

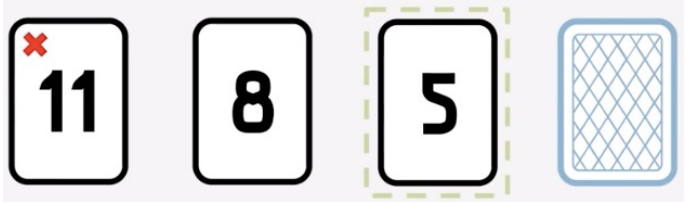
Wason selection task



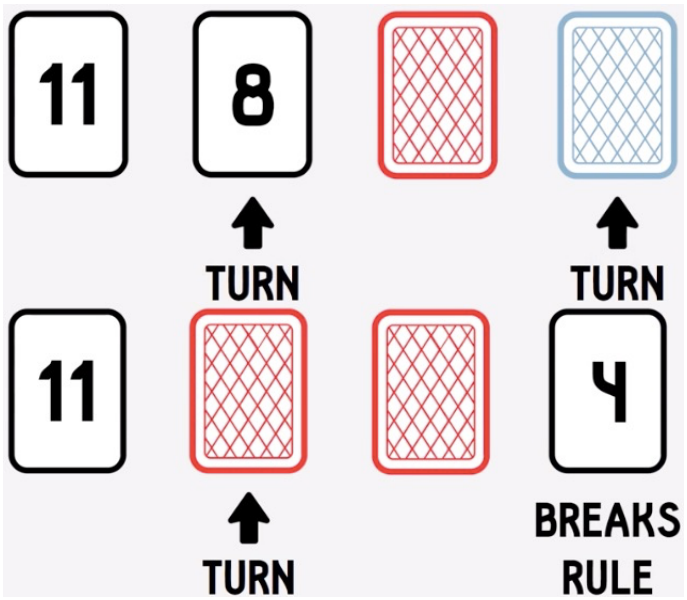
Task:

- You are shown four cards. For each card, each side has a number and the other side is coloured.
- **Rule**: if a card is even, it must be red.
- One of these cards breaks this rule and you must find out which.
- You can turn over any card you want, but if you choose a card which does not need to be inverted, it will count as a fail.
- Which card/s need to be turned over?

- The correct answer is to turn over the 8 and the blue card.
  - Remember, the rule was if the card was even on one side, it must be red on the other.
  - Since the rule is only about even numbers, we do not need to worry about cards with odd numbers.



- A common mistake is to turn over the red card, but if you turn over the red card, it does not actually break the rule. The rule was “only if the card was even did it have to be red”.



- You need to check the 8 to make sure it is red, and you need to check the blue card to make sure there is not an even number of the other side.

- 15% of people pick to flip the odd number card.
- 90% of people pick to flip the even number card.
- 60% of people pick to flip the red card.
- 25% of people pick to flip the blue card.

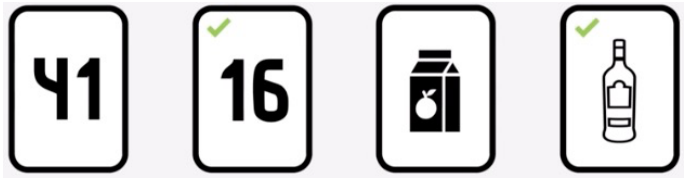
- Only 10% of people can make the right combination of choices (8 and blue).
- When presented with neutral material, people have particular difficulty in recognizing the importance of exploring the negation of the consequent.

Permission schema

- Performance on the selection task can be enhanced when the material has meaningful content.

Griggs and Cox (1982): 74%.

- You are presented with four cards.
- The cards represent four people drinking at a party. One side has the persons ages, and the other side has the persons drink.
- **Rule**: if you are under 18, you are not allowed to drink alcohol.



Which cards should you turn over?

- The correct answer is 16 and the vodka.
- We do not really care about the 41-year-old or the person drinking juice.
- All we care about is whether the 16-year-old is drinking alcohol and if the person drinking alcohol is over 18.

- People tend to be better at this version as the logical flows more naturally and the reasoning makes more intuitive sense.

- 74% of the participants in Griggs and Cox selected the logically correct combination.

Permission schema

Permission schema – if the problem context evokes a sense of permission, the reasoners can tap into their general knowledge induced from prior personal experience with permission-based scenarios.

- When the conditional statement is interpreted as a rule about what should be the case, performance on the Wason's selection task tends to be enhanced.
- "If you want to do P, then you must do Q".

Probabilistic interpretation

Why do we perform so poorly on the original Wason's selection task?

- People tend to select cards that will be informative under a probabilistic model, not a strict logical model.
  - If A, then B.
    → B will probably occur when A occurs.

Oaksford and Chater (1994).

- "If a car has a broken headlight, it will have a broken taillight."
- Which cars in the parking lot would you check?
    - If a car has a broken headlight, it will have a broken taillight.
    - Four choices:
        - **Cars with broken headlights** ← logically correct.
            - These cars have broken headlights so they must have broken taillights.
        - Cars without broken headlights.
        - Cars with broken taillights.
        - **Cars without broken taillights** ← logically correct.
            - If you find a car that has a broken headlight but intact taillight, it is a violation of the rule.
            - So, whenever you find a car that has an intact taillight, you have to check the headlight.
    - Finding cars that have broken headlights would be reasonable.
        - There would not be many of them anyway.
        - If you find one, it is necessary to check its taillight.
    - However, do you really want to check all cars that have intact taillights?
        - Cars with broken headlights/taillights are very rare.
            - Thus, if you find a car with a broken taillight, checking it to see whether it also has a broken headlight helps you make reasonable inference.
        - It is not a logical but an informative choice.

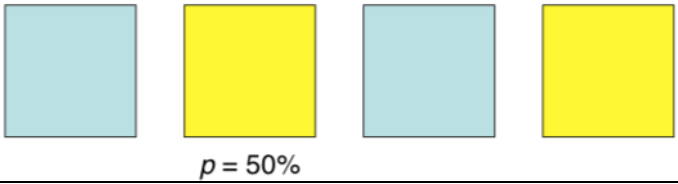
- We tend to interpret conditional statements on the basis of a probabilistic model, not a strict logical model because doing so actually makes sense in many situations in real life.
    - This might be one reason why making the correct (logical) choice in the original Wason's selection task is so difficult.

Reasoning about probabilities

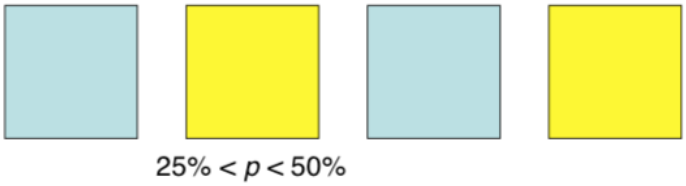
Reasoning ability about probabilities

Task:

- There are four boxes and just one of them contains a prize.
- You are to pick one box and see if it has a prize.
- Your chance of picking a box with the prize is 25%.



- New information: the smiley is always in one of the two yellow boxes.
- Your chance of picking the box with the prize is 50%.



- New different information: The smiley is in one of the two yellow boxes most of the time.
- Here, you cannot exactly say how likely you are to pick the box with a prize.
    - All you can say is it will be better than 25% but not more than 50%.

- **Prior probability** – the probability that a hypothesis is true before consideration of the evidence.
    - The base rate.
- **Posterior probability** – the probability that a hypothesis is true after consideration of the evidence.
    - Usually uses the words 'always', 'usually', etc.
    - To calculate the posterior probability, you need to take into account:
        - Prior probability (base rate).
        - Evidence.
        - How reliable the evidence is.
    - The correct logical math to determine the posterior probability.
        - Bayes' theorem – the evidence theorem.

Base-rate neglect

- People often fail to take base rates into account in making probability judgments.
- Hammerton (1973).
    - Suppose you take a diagnostic test for a rare form of cancer.
    - Only 1 in 10,000 people have this cancer.
    - This cancer results in a positive test 95% of the time.
    - If a person does not have the cancer, the probability of a positive result is 5%.
    - If you get a positive result, how do you feel about it?
        - Many people feel that the positive result means their chance of actually having the cancer is 95%.
        - However, the fact that this type of cancer is very rare (0.01%) is not taken into account.
        - The actual probability of having this cancer (given the positive result) is only 0.19%.

Judgments of probability

- We can be biased in our estimates of probabilities when we must rely on factors such as memory and similarity judgments.
- Tversky and Kahneman (1974).
    - Participants estimated the proportion of English words that:
        - Begin with *k* (e.g., kettle).
        - Have *k* in the third position (e.g., make).
    - More people estimated that more words begin with *k* than have *k* in the third position.
    - However, three times as many words have *k* in the third position as begin with *k*.

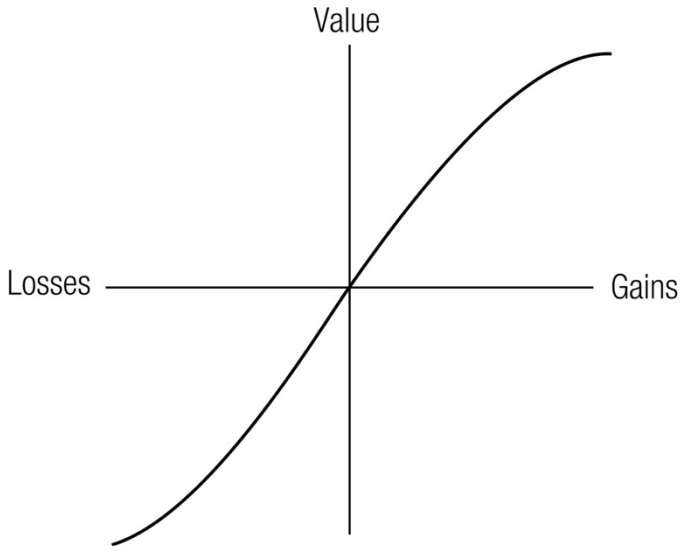
Decision making

Decision making

- You are given a choice of these two options. Which one would you choose?
    - $8 with probability of receiving that money being 1/3.
    - $3 with probability of receiving that money being 5/6; a lot higher.
- Expected average gain:
    - $8 with probability = 1/3.
        - $8 x 1/3 = $2.67.
    - $3 with probability = 5/6.
        - $3 x 5/6 = $2.50.

- Which one would you choose?
    - 1 million dollars with probability of receiving that money being 1.
        - $1 million x 1 = $1 million.
    - 2.5 million dollars with probability of receiving that money being ½.
        - $2.5 million x ½ = $1.25 million.

Subject utility



Subjective utility – the subjective value someone places on something.

- It usually forms a non-linear function.
- The subjective value decreases more steeply in negative direction.
- People make decisions under uncertainty in terms of subjective utilities and subjective probabilities.

Which one would you choose?

- 1 million dollars with probability = 1.
  - Ux1=U.
- 2.5 million dollars with probability = ½.
  - 1.2U x 1/2 = 0.6U.