**DECISION MAKING & REASONING:**

- **Induction vs. deduction:**
  - **Deduction: logically certain reasoning:**
    - If an animal has a liver, it must have a stomach.
    - Squirrels have livers, therefore squirrels have stomachs.

    - Thomas Bayes: We can quantify the degree to which we ought to believe a proposition.

    - Induction is just probabilistic reasoning

  - **Induction probable reasoning:**
    - Squirrels like nuts
    - badgers are similar to squirrels
    - therefore badgers probably like nuts.

    - My friend likes baseball and she likes football, so she probably likes basketball.
    - Induction reasoning is plausible.

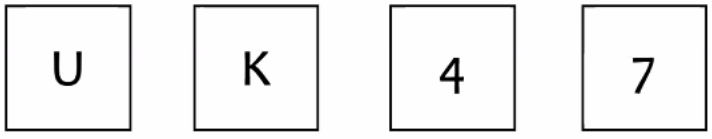
- **Models of Deduction:**
  - **Modus Ponens:**
    - A → B (if A then B)
    - A (A is true)
    - B (B is true)

    - A is the **Antecedent** and B is the **Consequent**.

  - **Modus Tollens:**
    - A → (if A then B)
    - ~B (B is false)
    - ~A (A is false)

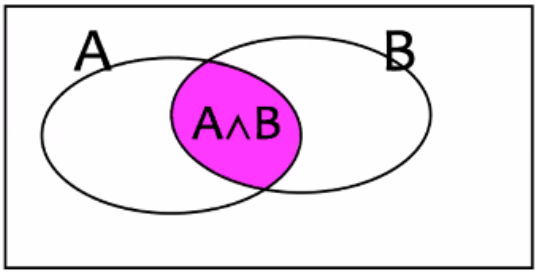
- **The Wason Selection Task:**
  - Each of these 4 cards has a letter on one side and a number on the other.
  -
  - **Your task is to evaluate the following rule:**
    - If there is a **VOWEL on** one side
    - There is an **EVEN NUMBER** on the other side.

    - VOWEL → EVEN. **Note**: V→E = ~V v E = ~(V ^ E)



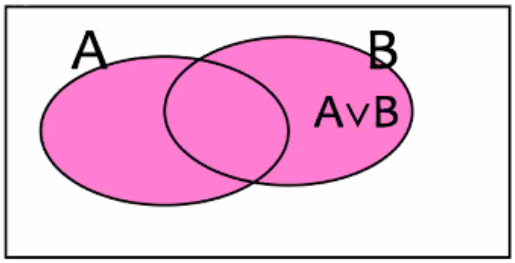
- **Conclusion:**
    - Human reasoners apparently can't reason deductively very well except in certain circumstances.
    - A deduction isn't all that useful in real circumstances anyway.
    - And many inferences we do make are not deductive.

- **Probability:**
    - A and B are propositions.
    - p(a) means "the probability that A is true" or "degree of belief in a."
    - p(A) is between 0 and 1.
    - p(~A) = 1 -p(A)
    - **Probability of Combined Propositions:**
        - p(A^B) = probability both A and B are true.
        - A^B is a subset of A.
            - 0 < p(A^B) < p(A) ← Conjunction rule



Conjunction of A and B

        - AvB is a subset of A.
            - 0 < p(A^B) < p(A) ← Disjunction rule



Disjunction of A and B

- **Conditional probability:**
  - p(A|B) means “probability of A given B is true.”
  - **Definition:** p(A|B) = $\frac{p(A \wedge B)}{p(B)}$
- **Bayes’ Rule:**
  - Conditional probability is the basis for inductive inference.
  - The conditional probability of a conclusion (hypothesis) H given premise (data) D is:

$$p(H|D) = \frac{p(H)\,p(D|H)}{p(D)}$$

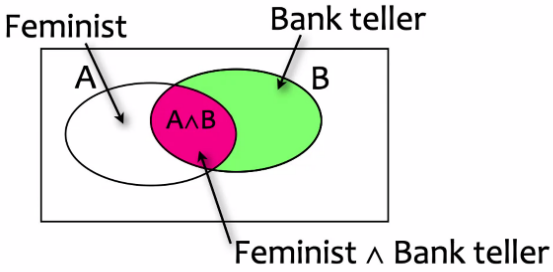
  - This is called Bayes’ rule and is useful for deciding how strongly to believe any inductive hypothesis on the basis of evidence and prior knowledge.
  - Bayes’ rule says: the posterior is proportional to the product of the prior and the likelihood (fit to the evidence).
- **Bayesian inference and rationality:**
  - Bayesian inference is the rational method for drawing inferences from experience–rational induction.
  - Bayesian inference is considered normative.
    - Objectively correct.
  - If people are “Bayesian”, that means they form beliefs in a way that is optimal given the information available.
  - If not, people are irrational, which means that they for in a way that is incoherent or internally inconsistent.
- **Are people Bayesian?:**
  - Prior to 1975, psychologists had never considered whether people were “Bayesian.”
  - However, economists widely assumed that people make optimal use of information, acting in their own rational self-interest.

- Starting in about 1975, psychologists began arguing that people are not, in fact, rational–and in particular that they are not Bayesian.

- So early tests of human rationality focused on situations in which people exhibited fallacies of reasoning, aka cognitive illusions.

- **The Conjunction Fallacy:**
  - Linda is 31 years old single, outspoken, and very bright.
  - She majored in philosophy.
  - As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in anti-nuclear demonstrations.

  - Rank the following propositions in terms of probability:
    - Linda is a teacher in elementary school.
    - Linda works in a bookstore and takes Yoga classes.
    - Linda is active in the feminist movement.
    - Linda is a psychiatric social worker.
    - Linda is a member of the League of Women Voters.
    - Linda is a bank teller.
    - Linda is an insurance salesperson.
    - Linda is a bank teller and is active in the feminist movement.




$0 \le p(A \wedge B) \le p(A)$ Conjunction rule

- **The representatives heuristic:**
  - A heuristic is an approximate strategy for solving a problem that is easier in some way than the optimal procedure.

- **The base rate fallacy:**

  - There was a taxi accident, and a witness saw a Blue (b) taxi.
  - 85% of the taxis in the city are Green, 15% are Blue
  - Reliability of witness is .8, implying $p(g|Green) = p(b|Blue) = .8$
  - What is the probability that the taxi involved in the accident was Blue?
  - If $p(Green) = .85$; $p(Blue) = .15$; $p(g|Green) = p(b|Blue) = .8$

$$p(Blue|b) = \frac{p(Blue)\,p(b|Blue)}{p(Blue)\,p(b|Blue) + p(Green)\,p(b|Green)} = \frac{(.15)(.8)}{(.15)(.8) + (.85)(.2)} = .41$$

  - But subjects typically say about 80%

- **Expected Value:**
  - The expected value is the long-run average value of something.

$$EV(x) = \sum xp(x)$$

  - Add up each value of x weighted by its probability.

  - 50% chance of 1 inch of ran = Expected: .4 inches.
    - = (.5) * (1 inch) + (.5) * (0 inches) = .5 inches

  - 1 in a million chance o a $327 million lottery = $327 dollars.
    - = (1/1,000,000) & ($327 million) + (999,999/1,000,00) * $0
  - The rational prce of a bet is its expected value.

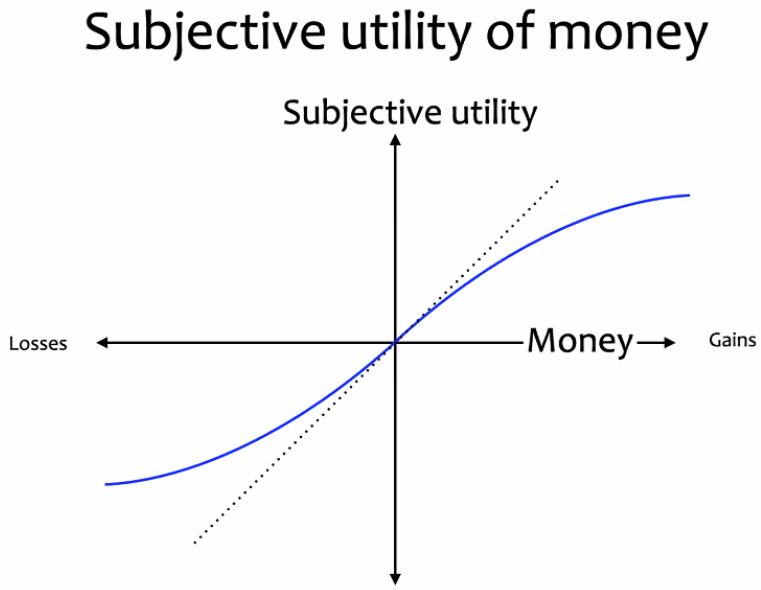
- **Risky Decisions:**
  - **Which do you prefer:**
    - 100% chance of $10
    - 50% chance of $20.

  - **Expected values are the same:**
    - 1($10) = .5($20) = $10.
    - But most people prefer the sure thing (the certain gain).
    - EV = .99($12) = .01($-100) = $10.88

    - **Risk Aversion:**
      - Preference for a certain gain over an uncertain loss.

- **Subjective Utility:**
    - The subjective utility is how desirable something is to a particular person.

    - **A rational principle for decision making:**
        - Maximize expected utility.
        - For each choice x evaluates u(x) and p(x) and makes the choice with the largest Σp(x)u(x).]




- Decision theory (expected utility) is rational and normative but not descriptive.

- Instead bounded rationality aka satisfciing.
- Choose the first option that is not good enough.
    - EX: Choose ethe first restaurant that you can all agree on,
- Decide based on on feature only.