DECISION MAKING

• What is it?
  • “a task where
    • a person must select one choice from a number of choices
    • there is some amount of information available with respect to the choices
    • the time frame is relatively long (longer than a second), and
    • the choice is associated with uncertainty …”
    (from Wickens et al, pg. 157)

• How does it happen?
  • classical vs naturalistic
  • analytical vs intuitive

Jack is a 55-year old married man with four children. He is generally conservative, careful, and ambitious. He shows no interest in political and social issues and spends most of his free time on his many hobbies which include home carpentry, sailing, and mathematical puzzles.

Please rank order the following statements by their probability, with 1 being the most probable and 4 being the least probable.

___ Jack is a lawyer
___ Jack is an engineer
___ Another of Jack’s hobbies is playing jazz
___ Jack is a reporter
The mean IQ of the population of eighth graders in a city is known to be 100. You have selected a random sample of 50 children for a study of educational achievements. The first child tested has an IQ of 150. What do you expect the mean IQ to be for the whole sample?

Mr. Crane and Mr. Tees were scheduled to leave the airport on different flights at the same time. They traveled from town in the same limousine, were caught in a traffic jam, and arrived at the airport 30 minutes after the scheduled departure of their flights. Mr. Crane is told that his flight left on time. Mr. Tees is told that his flight was delayed and just left 5 minutes ago.

Who is more upset?
A model of decision making

Classical decision theory

- Based on the concept of *optimal, rational* decision making.
  - Decision makers
    - seek to *optimize* the outcome.
    - use *rational* approaches to do this.
  - Decision making research in this framework focuses on understanding deviation from optimal, rational decision making.
- Several approaches are used:
  - Expected Utility
  - Multi Attribute Utility Theory
  - Bayes’ Theorem
What was your response?

- What is the order you gave for the probability of the statements about Jack?
  - ___ Jack is a lawyer
  - ___ Jack is an engineer
  - ___ Another of Jack's hobbies is playing jazz
  - ___ Jack is a reporter

- What do you expect the mean IQ to be for the whole sample?

- Who is more upset?

Heuristics & biases in judgement
(from: Kahneman & Tversky, 1980)

- Anchoring & adjustment
  - giving too much weight to early evidence and too little to later evidence.

- Number of sources
  - tend to demand as many sources of information as possible, but performance usually doesn't improve.

- Overconfidence in judgement
  - unwarranted confidence in our own ability
    - e.g., eyewitness testimony, "Where were you when ...?"

- Self-fulfilling prophecy (confirmation bias)
  - Tend to look at data that favors a certain outcome and ignore other evidence; bias to look for only confirming evidence.
• **Representativeness**
  - Categorize stimulus or event based on how typical or representative it is of a class of stimuli.
  - *Using a stereotype to judge a particular thing*
    - “Bill must be an EE because he’s a real geek …”

• **Data saturation**
  - *Creating a stereotype, generalizing from particular things*
    - “I met George and Louise. Both are EE’s. Both are geeks. Therefore, EE’s are geeks.”

• **Availability**
  - We base judgements of frequency on how easily instances or examples come to mind (how available are examples in our memory.)
  - Often a good rule of thumb, but confounded with recency and vividness.

• **Imaginability**
  - Base judgments based on how easy is it to imagine a particular outcome.
  - Also confounded with recency and vividness.

• **Fundamental attribution error**
  - My success is due to my own intelligence, etc.
  - My failure is due to bad luck, circumstance.
  - Your success is due to good luck, circumstance.
  - Your failure is due to lack of planning, ability, etc.

• **Gambler’s fallacy**
  - Unexpected “run” of some event increases the chance that some other event will occur.
  - A form of the representativeness heuristic: a representative sequence of events reflects the long-term probabilities.
Classical decision analysis

Identify the situation and understand objectives.

Identify alternatives.

Decompose and model the problem.

Choose the best alternative.

Sensitivity analysis.

Is further analysis required?

Yes

No

Implement the chosen alternative.


Classical methods: Expected utility

- Compare options based on utility
  - $E(u) = \sum p_v y_i$
  
- Select option with highest expected utility

- Example:
  - Choosing a computer-based business:

<table>
<thead>
<tr>
<th>Option</th>
<th>Probability, p</th>
<th>Value, v</th>
<th>Option</th>
<th>Probability, p</th>
<th>Value, v</th>
</tr>
</thead>
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<tr>
<td>High Return</td>
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<td>$100</td>
<td>0.10</td>
<td>$700</td>
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<tr>
<td>Medium Return</td>
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<td>90</td>
<td>0.25</td>
<td>200</td>
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<tr>
<td>Low Return</td>
<td>0.45</td>
<td>5</td>
<td>0.65</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
Classical Methods: Multi-attribute utility theory

- AKA *merit analysis*!
- Determine expected utility of alternatives based on several attributes.
  - ‘merit criteria’
- Utility based on relative weight of each attribute and the score given each alternative on each attribute.

Updating probabilities: Bayes’ theorem

- Understanding the effect of base rates on the probability of an outcome.
- Example:

  Two cab companies operate in the city. 85% of the cabs are operated by the MeFirst Cab Company and the rest are from Running Meter Cabs. One night a cab was involved in a hit-and-run accident. A witness identified it as a Running Meter Cab. Tests of nighttime visibility showed that the witness is able to correctly identify a cab at night 80% of the time. What is the probability that the witness correctly identified the cab the night of the accident?
Assumptions of classical approaches:

- Goals can be isolated.
- Utilities can be assessed independent of context.
- Probabilities can be accurately estimated.
- Choices, goals, and evidence can be carefully and clearly defined.
- There is adequate time to assess/update/calculate probabilities, utilities, etc.

Examples of classical decision making:

Normative approaches don't work when:

- The problem is ill-structured
- Goals are vague
- There are multiple players
- The environment is dynamic
- There is uncertainty
- There is high time stress

Examples:
Naturalistic decision making

- **Naturalistic** approaches seek to understand and aid decision makers under these conditions.
  - (Examples: pilots in emergency situations, firefighting, aircraft carrier crews …)

- Several models, including:
  - Recognition-Primed Decision Making (Klein)
  - Skills, Rules, Knowledge Model (Rasmussen)
  - Decision Ladder (Rasmussen)
  - Analogical Problem Solving (Gick and Holyoak)

- Basic Idea:
  - Solve the current problem by recognizing that it is similar to some previous problem(s) and applying or adapting a previous solution.
  - Relies on a strong perceptual-recognitional component that is holistic, parallel, and contextual.
  - Emphasizes situation assessment: Identifying and clarifying the current state of the world, including the goals and assumptions.

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Klein's RPD model:

Features of the RPD model

- Experienced decision makers can
  - directly generate possible options.
  - serially generate and evaluate options in turn (without contrasting options).
  - use *satisficing* rather than optimization.
- Evaluation can involve mental simulation (involving context information.)
- Emphasizes situation assessment, rather than the actual choice process.

Example: Klein et al. studied how experienced firefighters made decisions about resource allocation. The firefighters did not calculate the relative costs and benefits of alternative strategies. Instead, they recognized the situation as a match to some typical or standard case, and then acted on it.

Rasmussen's SRK model
(Skills, Rules, Knowledge)

Knowledge-Based Behavior

- Symbols
- Identification
- Decision of Task
- Planning

Rule-Based Behavior

- Recognition
- Association State/Task
- Stored Rules for Task

Skill-Based Behavior

- Feature Formation (Signs)
- Sensory Input
- Automated Sensory-Motor Patterns
- Signals
- Actions
Summary: Designing to aid decision makers

- Design of decision aids based on the *classical* approach
  - Expert systems approaches.
  - Incorporate algorithms to automatically assess/update probabilities.
  - Methods of assessing and normalizing relative utility/merit of alternatives.
  - The goal is to overcome natural human biases in order to improve the quality of the decision.

- Applications:
  - maintenance systems
  - stock market analysis systems
  - ...
Designing to aid decision makers

- Design of decision aids based on the naturalistic approach
  - Design systems, displays, and controls to maximize situation awareness.
  - Design training to improve situation assessment, provide a "toolbox" of potential solutions, and improve solution evaluation and selection.
  - Design aids to perform complex calculations, update probabilities, evaluate utilities, and provide information to the decision maker.
  - Display information in an integrated, relevant, and useful form; provide information in a timely manner.
- Design of decision aids based on an integrated approach
  - See page 177-183 of your text for a detailed list of suggestions.

A related issue - PROBLEM SOLVING

- One viewpoint - decision making is a type of problem solving
  - An alternative viewpoint - problem solving is what happens when you enter into the knowledge-based mode of decision making.
  - Regardless of the viewpoint, designing to aid problem solving involves the same approach as designing to aid decision making.
A famous experiment in analogical problem solving (Gick & Holyoak, 1980)

The Attack-Dispersion Story:
A general wants to capture a fortress in the center of a country. Many roads lead to the fortress. The roads have been mined such that small groups of soldiers can pass through safely, but any large force will detonate the mines. The general's solution: divide the army into small groups, send each group on a separate road, and have the groups converge simultaneously on the fortress.

Analogical problem solving, pt. 2

The Radiation Problem:
You are a doctor. Your patient has a malignant inoperable tumor in the stomach. Your only choice is to use radiation therapy. If the rays reach the tumor all at once at a sufficiently high intensity, the tumor will be destroyed. But at this intensity the rays will also destroy all healthy tissue through which they pass. Rays at a lower intensity will not harm healthy tissue but will not be strong enough to kill the tumor. How can you kill the tumor without harming healthy tissue?
Findings of research in analogical problem solving

- Problem solvers can spontaneously use solutions to previously seen problems when solving novel problems.

- The degree of success depends on the "closeness" of the problem.

- Problem solvers easily draw surface feature analogies, but must be trained to look for deeper connections.

- Performance improves as more and "closer" analogies are given.

- Applications:
  - training systems
  - examples and homework

Implications for system design

- Present information in a form that promotes effective situation assessment (i.e., necessary information is displayed in a meaningful way, similarities between current and previous problems are readily apparent.)

- Training based on experience with a wide range of scenarios.

- Procedures that standardize information gathering in a way that emphasizes the similarity between the current and previous situations.