Decision Making

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Lecture 17a
Overview

• Decision Making
  – Information processing and Signal Detection Theory (P&V, Chapter 4)
  – Normative and descriptive models of judgments and decisions
  – Naturalistic decision making

• The FAA from a Human Factors Perspective
Examples of Signal Detection Tasks

• Determining sensory thresholds
• Airport security screening
• Identify friend or foe
• Lie detectors
• Detecting cancerous cells

What are the common threads?
These are situations that are not clear cut. Some errors and some correct choices are made. Speed of response is not a factor, accuracy is the focus. Training/practice can be a factor.
Key Terms

• Sensitivity (d’)
  – Ability to separate the signal from noise
  – Better (higher) with practice, for an easier task, or for particular individuals

• Bias (β) (criterion)
  – Conservative vs. liberal
    (accept nothing vs. accept everything)
Signal detection theory

State of World

Operator Behavior

"Yes" (signal seen)
"No" (No signal perceived)
Response bias "Yes" vs. "No"

Signal Present (+Noise)
Hit (H) P (H)
Miss (M) 1-P(H)

False Alarm (FA) P (FA)
Correct Rejection (CR) 1-P(FA)

Sensitivity Low vs. High

Image by MIT OpenCourseWare.
Good sensitivity:
High hit rate + low FA
Bad sensitivity:
Same number of hits and FA
Data for an ROC Curve

• To generate different points on the curve (i.e., to vary bias), alter
  – Subject instructions to be more or less conservative
  – Payoffs for hits/misses
  – Base frequencies of signal occurrence
Relations to hypothesis testing

- Null hypothesis, H0: the signal is absent from the data
- Alternative hypothesis, H1: the signal is present
- There are two kinds of errors:
  - Type I: choosing H1 when H0 is true => FA
  - Type II: choosing H0 when H1 is true => Miss

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Signal detection theory

Picture from: http://www.csic.cornell.edu/201/signal_detection/

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"Figure 4: Internal response probability of occurrence curves and ROC curves for different signal strengths." Image removed due to copyright restrictions. Original image can be viewed here: [http://www.cns.nyu.edu/~david/handouts/sdt/sdt.html](http://www.cns.nyu.edu/~david/handouts/sdt/sdt.html).
Signal Detection Links

• Demonstration

• To create graphs by entering data
  – http://wise.cgu.edu/sdtmod/index.asp

• To manipulate graphs interactively
Observations about “Simple” Judgments and Decisions

• Examples
  – What can I guess about someone I just met?
  – Are people in Minnesota taller on average than people in Massachusetts?
  – What should I wear today?
  – Should I buy a lottery ticket? (and other financial decisions)

• Common Threads
  – Not a lot of formal reasoning
  – Specific data are accessible/available/known, but not always considered accurately (cognitive biases)
  – Make the judgment/decision and move on (tactical)
Normative vs. Descriptive Models

Normative Models
• List options
• Remember, gather, perceive all associated information and cues
• For each option, list possible outcomes
  – Costs
  – Benefits/values
  – Risks
• Assign probabilities
• Chose option with highest utility (Bayesian logic)

Descriptive Models (Realty)
• Use heuristics
• May not think of all options
• Resource limitations
  – Incomplete information
  – Time constraints
  – Cognitive
    • Memory
    • Attention
• May be biased
  – Transitivity & framing
  – Bounded rationality
  – Satisficing
Reasoning

• Deductive reasoning
  – Formal logic
    \[ x \rightarrow y \]
    If x then y.
    \[ \neg y \]
    “not y”
    \[ \therefore \neg x \]
    Therefore “not x.”

• Inductive reasoning (generalization)
  – Drawing a conclusion from a set of data
  – Basis for scientific reasoning, prototyping, classification into groups, and analogy-based reasoning
Example: Hypothesis Testing

• You have a deck of cards with colors on one side and animals on the other.
• Hypothesis:  
  All cards with a 4-legged animals are green on the back.
• Which cards would you flip over to test your hypothesis?

Rabbit Green Duck Red
Heuristics and Cognitive Biases

• Hindsight bias, Gambler’s fallacy, sunk costs, and many others

• Availability and representativeness heuristics
  – Tversky & Kahneman

• Hypothesis testing
  – Confirmation bias
    • e.g., watching a particular news outlet
    • Also, automation bias
Naturalistic Decision Making

- Ill structured problems
  - Uncertain dynamic conditions
- Shifting goals
- Action feedback loops
- Time pressure
- High risk
- Multiple players
- Organizational norms
- Domains: Military command and control, aviation, emergency/first response services, process control, medicine

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Complex/Naturalistic Decisions

• Examples
  – Should I fly today or not? (go/no-go decision)
  – While airborne, should I continue my flight or land?
  – What career should I pursue?
  – What should I do when events don’t go as planned?

• Common threads
  – On-going/continuous decision making (strategic)
  – Plenty of thought/data collection, mental modeling, and projection (situation awareness)
  – Personality is a factor
Decision making is a continuous process
  – Anticipate, recognize, evaluate options, act (repeat)

Keep on guard, pessimism is good

Slow emergencies vs. fast emergencies
  – e.g., flight into IMC vs. engine failure

Rehearse, practice, checklists
  – Aviate, navigate, communicate, and “hesitate”
  – Think through the problem, analyze

http://www.aopa.org/asf/webinars/
• Priorities
  – Survive unharmed, save the aircraft, reach your destination
• Making the best decision (maybe out of all bad options)
• Aeronautical decision making factors
  – “Hazardous attitudes”
    • Macho, antiauthority, impulsivity, invulnerability, resignation
  – Experience, a double edged sword
  – External pressures (e.g., what others expect/say/do, time to return aircraft)

http://www.aopa.org/asf/hotspot/decisionmaking e.g., audio at 24:20
• Know your own ‘weak spots’
• Have a backup plan
• Under-promise
• Be well prepared before the flight

Image of N3609 crash removed due to copyright restrictions.

The investigation begins...
Cognitive Control Modes

Automatic ← Conscious

Skill Based → Rule Based → Knowledge Based

Routine

Situation

Novel

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Expert Decision Making

• Experts tend to develop a single option as opposed to multiple
  – Satisficing vs. optimal
  – Experts vs. novices

• Recognition primed decision making
  – Naturalistic decision making
  – Pattern recognition
    • Mental Simulation
  – Cues
  – Expectancies
  – Goals
  – Action

Image of airplane water landing removed due to copyright restrictions.

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