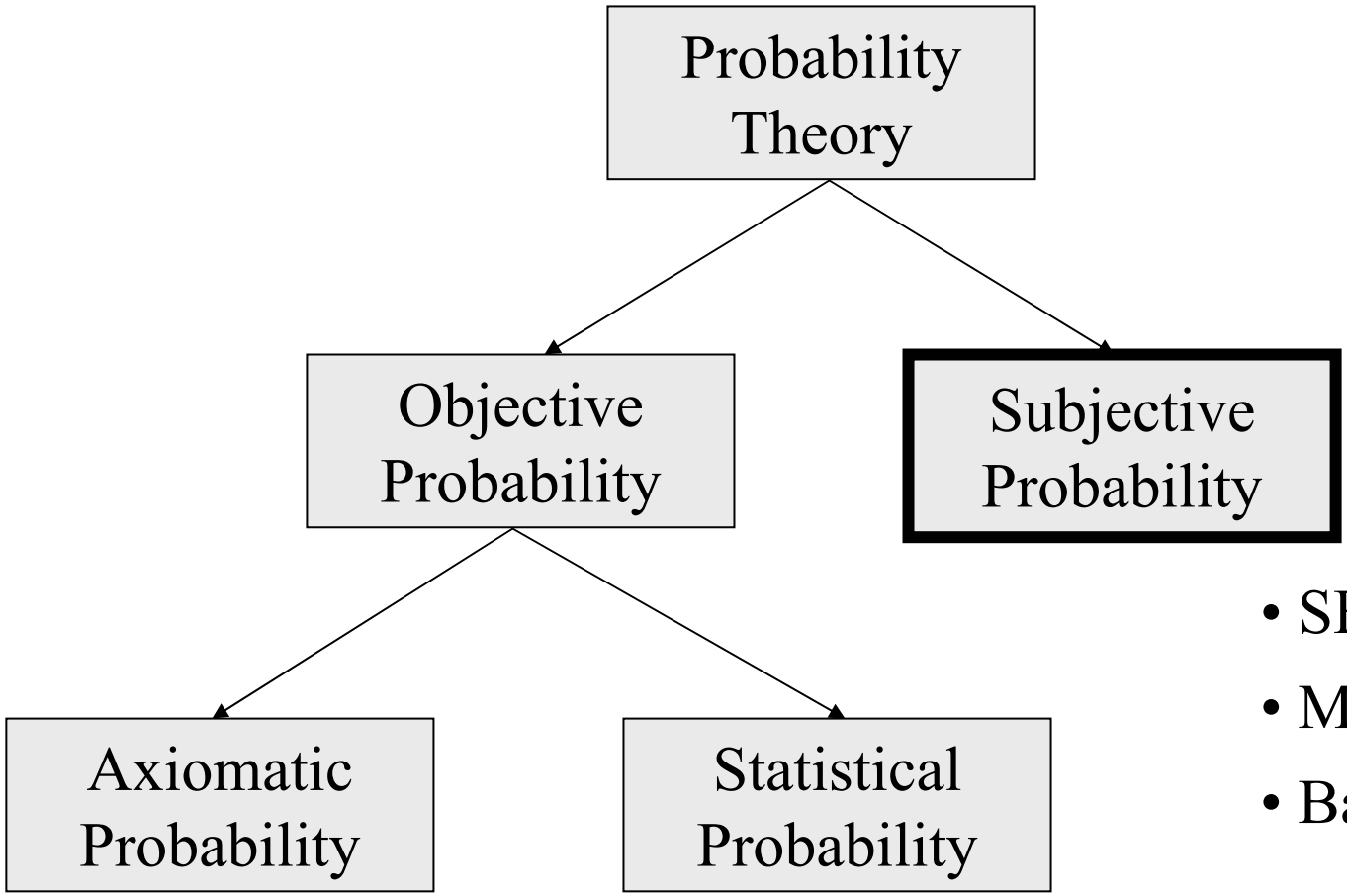
16.422

Human Supervisory Control

Judgment Under Uncertainty: Heuristics & Biases

Massachusetts Institute of Technology

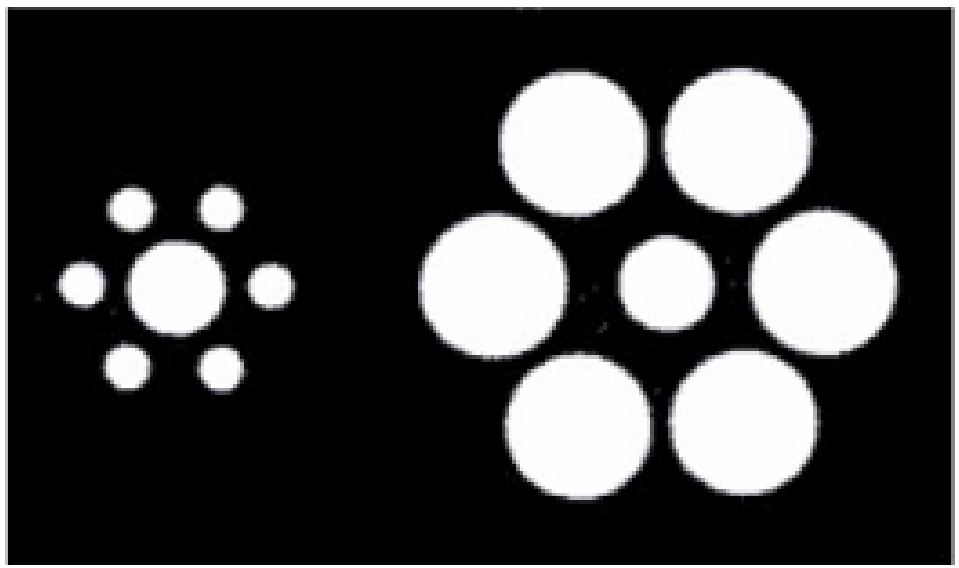
The Uncertain State of the World



- SEU
- MAUT
- Bayesian Nets

Subjective Assessment

- Subjective assessment of probabilities is akin to assessment of size and distance
- Perception versus expectation
- Heuristics are useful but can be misleading



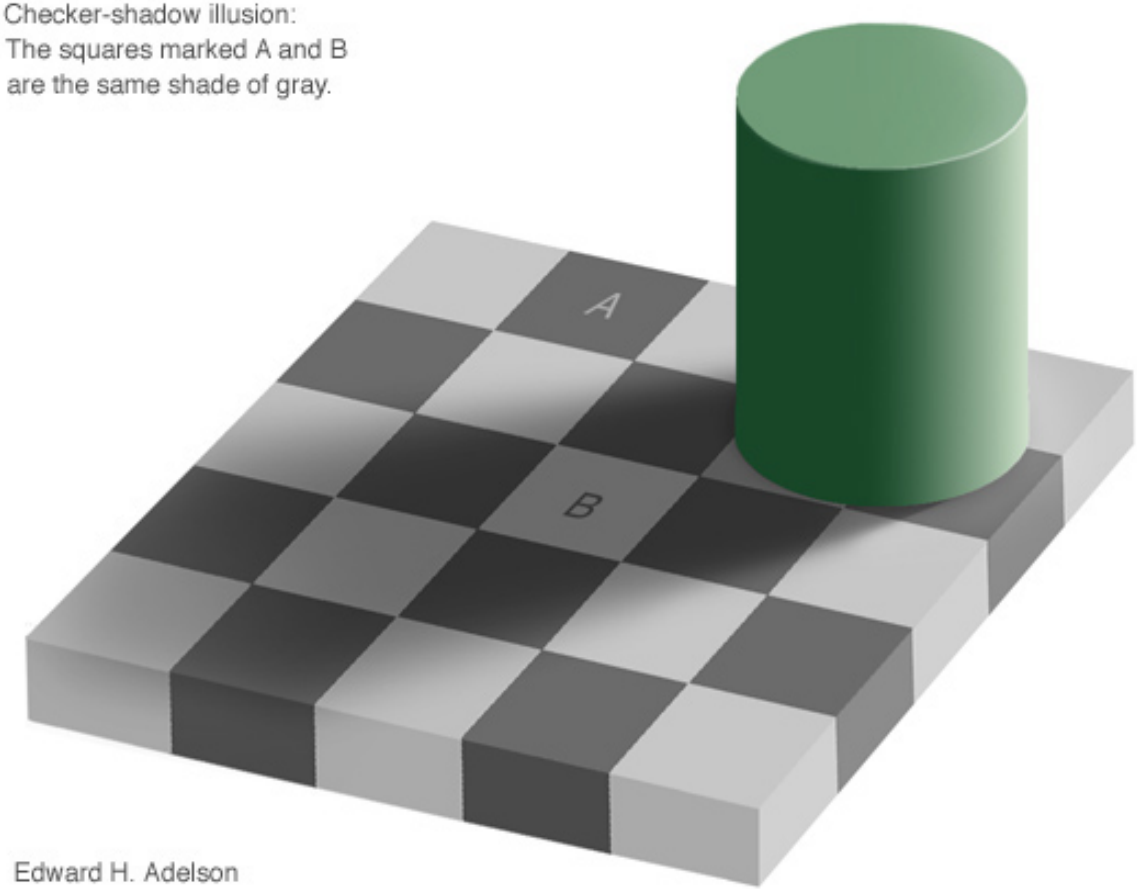
The Ames Room

(Image removed due to copyright considerations.)

http://psylux.psych.tu-dresden.de/i1/kaw/diverses%20Material/www.illusionworks.com/html/ames_room.html

Expectations Can Fool You…

Checker-shadow illusion:
The squares marked A and B
are the same shade of gray.



Edward H. Adelson

Human Estimation & Cue Integration

- Humans as intuitive statisticians
  - Good at estimating means, reasonably good at mid-range proportions
    - Not good on the tails
  - Not so good at estimating variances and correlations
  - Also not good at extrapolating non-linear trends
    - Underestimate exponential growth
- Cue assimilation issues
  - Missing
  - Information overload
  - Salience
    - Underestimate cues that require calculation
  - The need for heuristics

As-if Heuristic

- Cues are equally weighted and differential weights are not considered
  - Regression to the mean
  - Reliability of cues
  - Letters of recommendation – content v. tone
- Humans are poor intuitive or clinical predictors as compared to computers
  - Multiple cues of different information value
- Cognitive parsimony
  - Humans tend to reduce load on working memory.
  - Avoid processing of cues that require mental calculation

Representative Heuristic

- Probabilities are evaluated by the degree to which A resembles B
- Problems
  - Prior probability (or base-rate frequency) of outcomes
    - Engineers vs. lawyers
    - No specific evidence vs. worthless evidence
  - Insensitivity to sample size
    - Large vs. small hospital
  - Misconceptions of chance
  - Insensitivity to prediction
  - Illusion of validity
    - Stereotypes
  - Regression to the mean

Availability Heuristic

- Assessing probability or frequency bases on information that is most readily recalled
- Problems:
  - Retrievability of instances
    - Familiarity, salience, recency – driven by experience
  - Effectiveness of a search set
    - Searching for solutions in your long term memory
  - Imaginability
    - Simplicity
    - Decision making & alternatives
  - Illusory Correlation
    - How frequently two events co-occur

Effectiveness of search set….abstract words as opposed to concrete

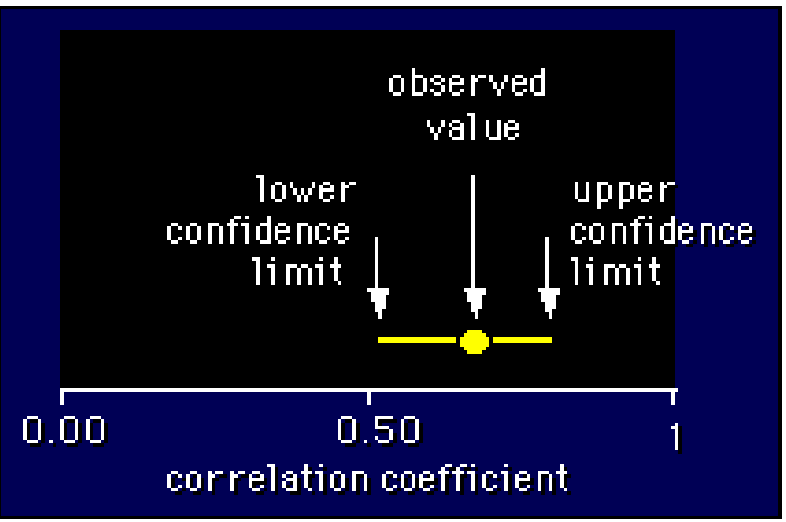
Adjustment &Anchoring Heuristic

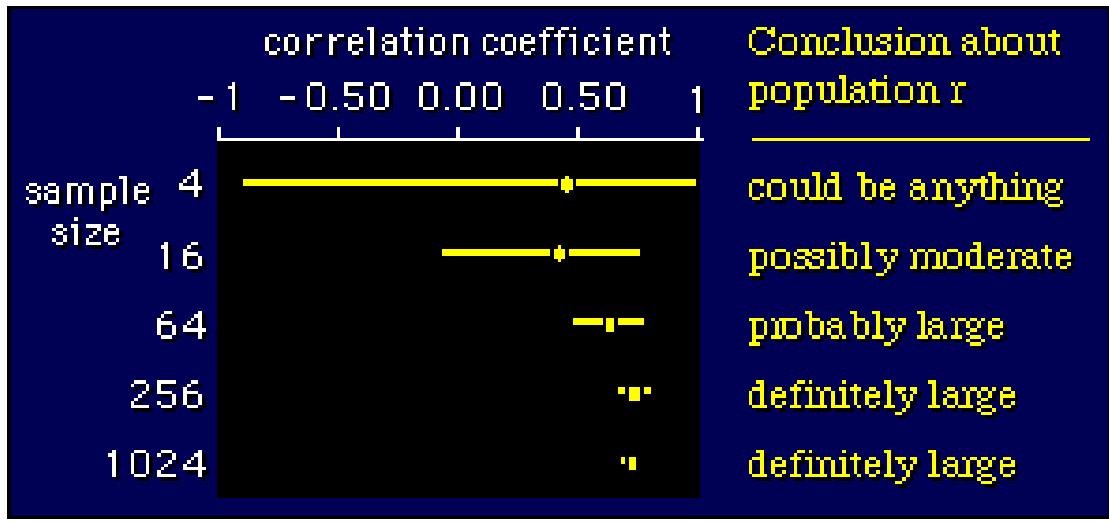
- People start with an initial guess and adjust answers based on available information
- Problems
  - Insufficient adjustment
    - 1x2x3x4x5x6x7x8 v. 8x7x6x5x4x3x2x1
    - 512, 2250, 40320
  - Evaluation of simple, conjunctive (and) & disjunctive (or) events
    - Overestimate conjunctive, underestimate disjunctive
  - Ordering matters
  - Assessment of subjective probability distribution
    - Overly narrow confidence intervals

Simple – draw red from bag 50/50 red and white
Conjunctive – draw seven successive reds from a bag 90/10
Disjunctive – draw a red at least once in seven tries from a bag 10/90
.50/.48/.522

Confidence Intervals

- A confidence interval gives an estimated range of values which is likely to include an unknown population parameter, given set of sample data.
  - The confidence interval is the likely range of the true value.
- Precision determined by the width of the confidence interval





(Courtesy of Will Hopkins. Used with permission.)

• http://www.sportsci.org/resource/stats/generalize.html

Some Other Biases

- Overconfidence Bias
  - Confidence exceeds prediction accuracy
  - Prevents people from seeking additional information/cues
- Confirmation Bias
  - People seek information that supports a preformed hypothesis
    - Do not seek or discount contrary information
- Automation Bias
  - People tend to believe computer recommendations and do not seek out conflicting evidence

Effectiveness of search set….abstract words as opposed to concrete

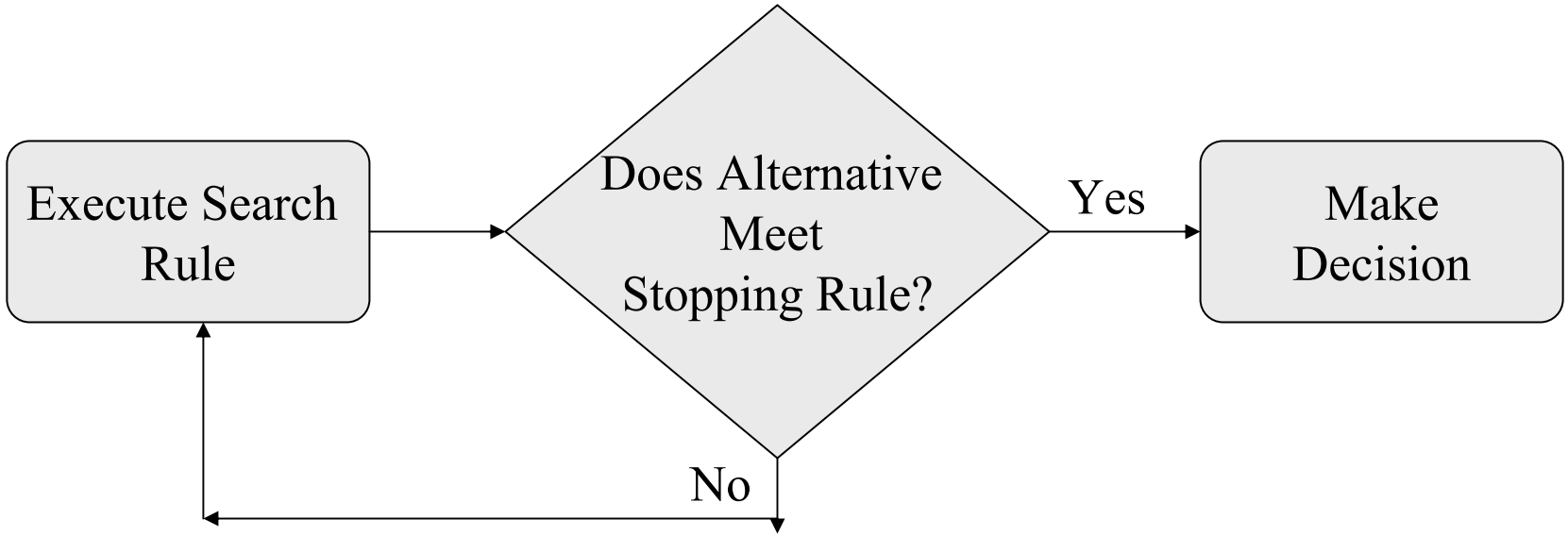
Framing Effect

- Prospect theory - People value a certain gain more than a probable gain with an equal or greater expected value; the opposite is true for losses.
  - Would you rather win (or lose) $1 and 0% risk or $2 with 50/50 risk?
  - Take the sure thing?
- Framing Effect: Choices are made differently depending on whether the choices are framed in terms of gains or losses
- Sunk cost bias
- How does this impact design?

Bounded Rationality

- Criticism for the application of classical decision theory
  - Unbounded rationality - humans make rational decisions, but they do so without time constraints, with complete *a priori* knowledge, and unlimited computational abilities
- Bounded rationality: concept of satisficing, which occur when decision makers stop the search for a solution when the first alternative is found that meets all constraints
  - Probably not the optimal solution
- Fast & frugal heuristics

Fast & Frugal Heuristics



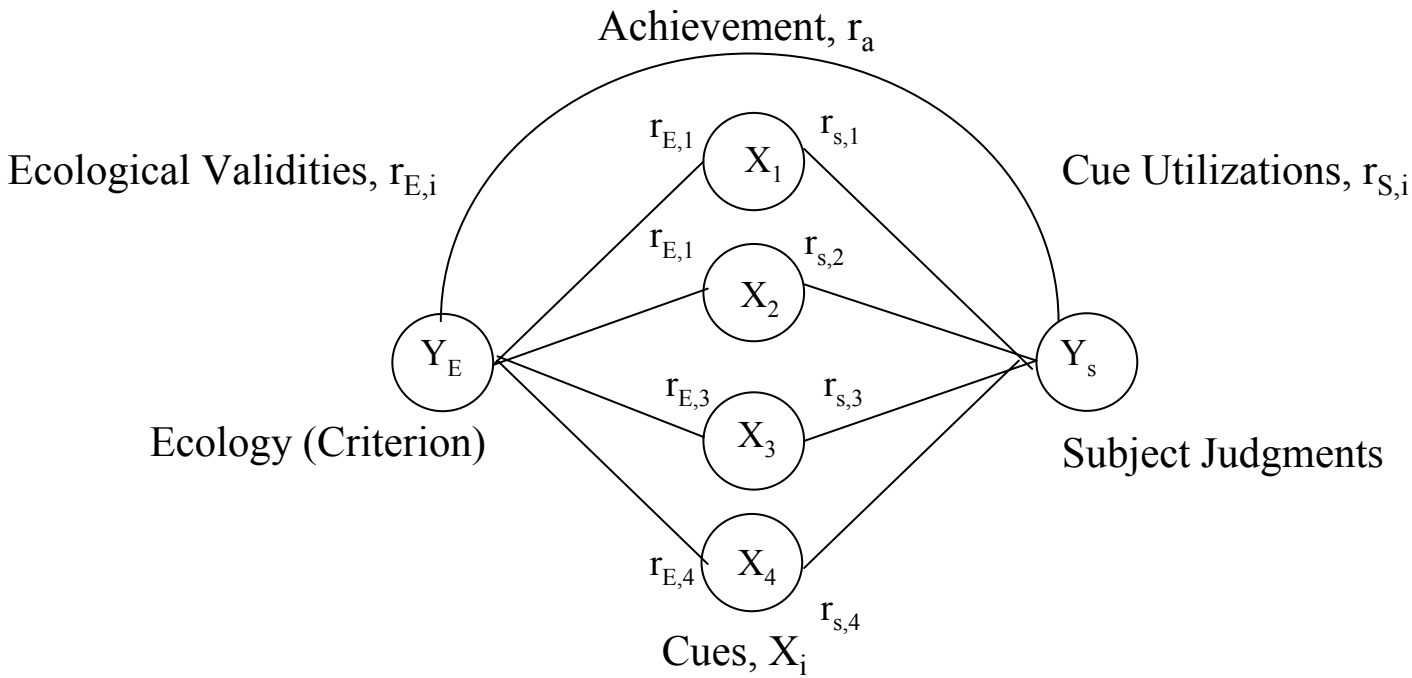
- Some search rules:
  - Take the last
    - The decision that worked for this problem *last* time
  - Take the best
    - Consider primarily the cue with highest validity
- Seed for recognition primed decision making

Implications for Design

- Ways to combat problems with decision biases:
  - Training
  - Emphasis on feedback
    - Ambiguous/Delayed/Selective processing
  - Debiasing
  - Proceduralization
  - Development of decision aids
- Decision guidance
  - Interactive
  - Participative-suggestive
  - Jiang & Klein paper

Social Judgment Theory

- SJT attempts to model human decision-making using classical decision theory through an ecological approach.
- Lens Model
  - Attempt to model how well a person's judgments match the environment they are trying to predict.



More on the Lens Model

- Uses regression
  - Prediction (dependent) from cues (independent)
  - Determines not only the degree of agreement between a human judge and the state of the environment, but also the predictability of the environment as well as the level of consistency of human judgments.

$$Y_s = \text{Predicted Model} + \text{Model Error} = \hat{Y}_s + e$$

$$r_a = GR_eR_s + C\sqrt{(1-R_e^2)}\sqrt{(1-R_s^2)}$$

- Problems:
  - Assumption that relationship is linear
  - Identification of cues

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