

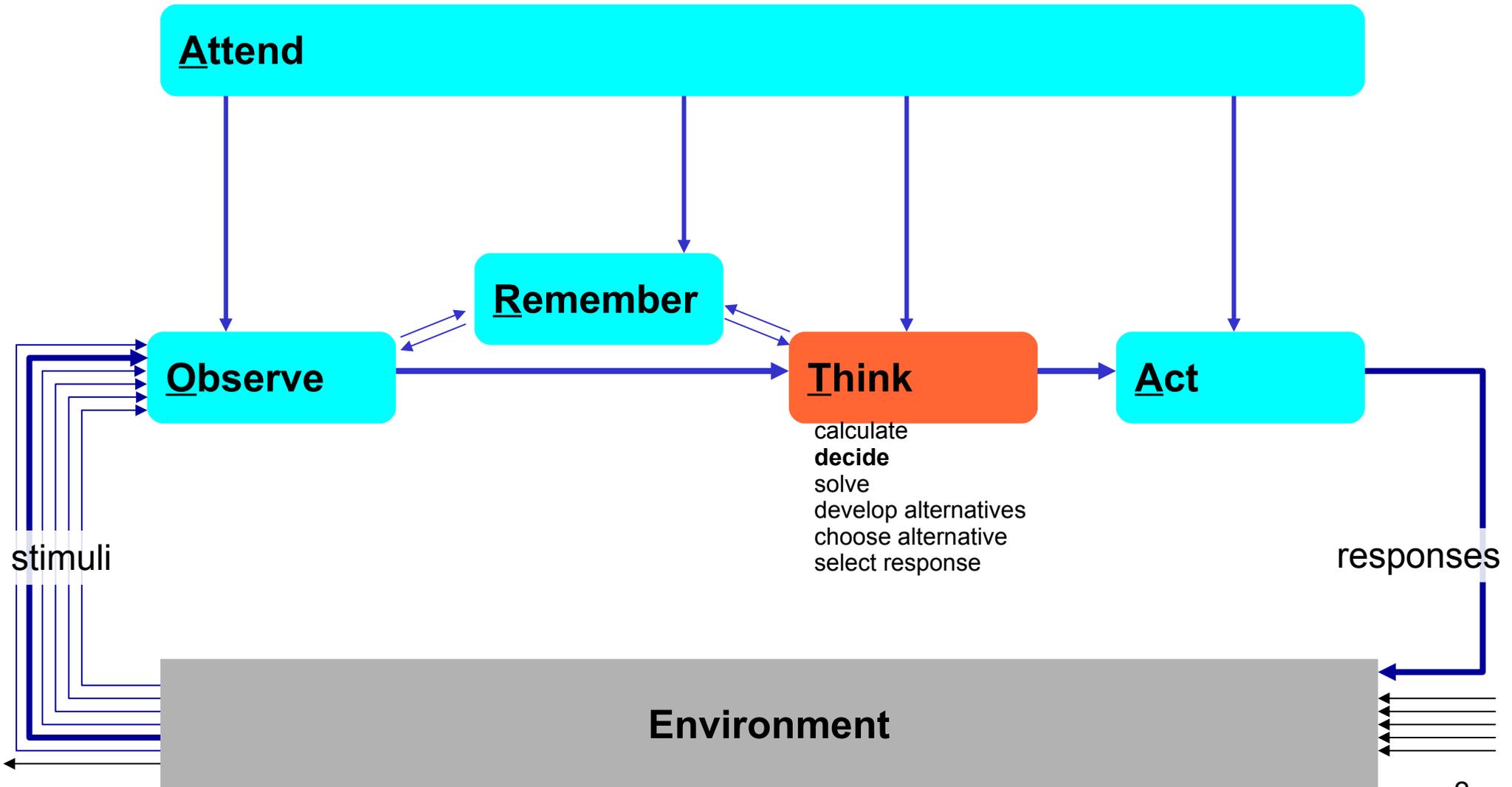
# IE 545, Human Factors Engineering

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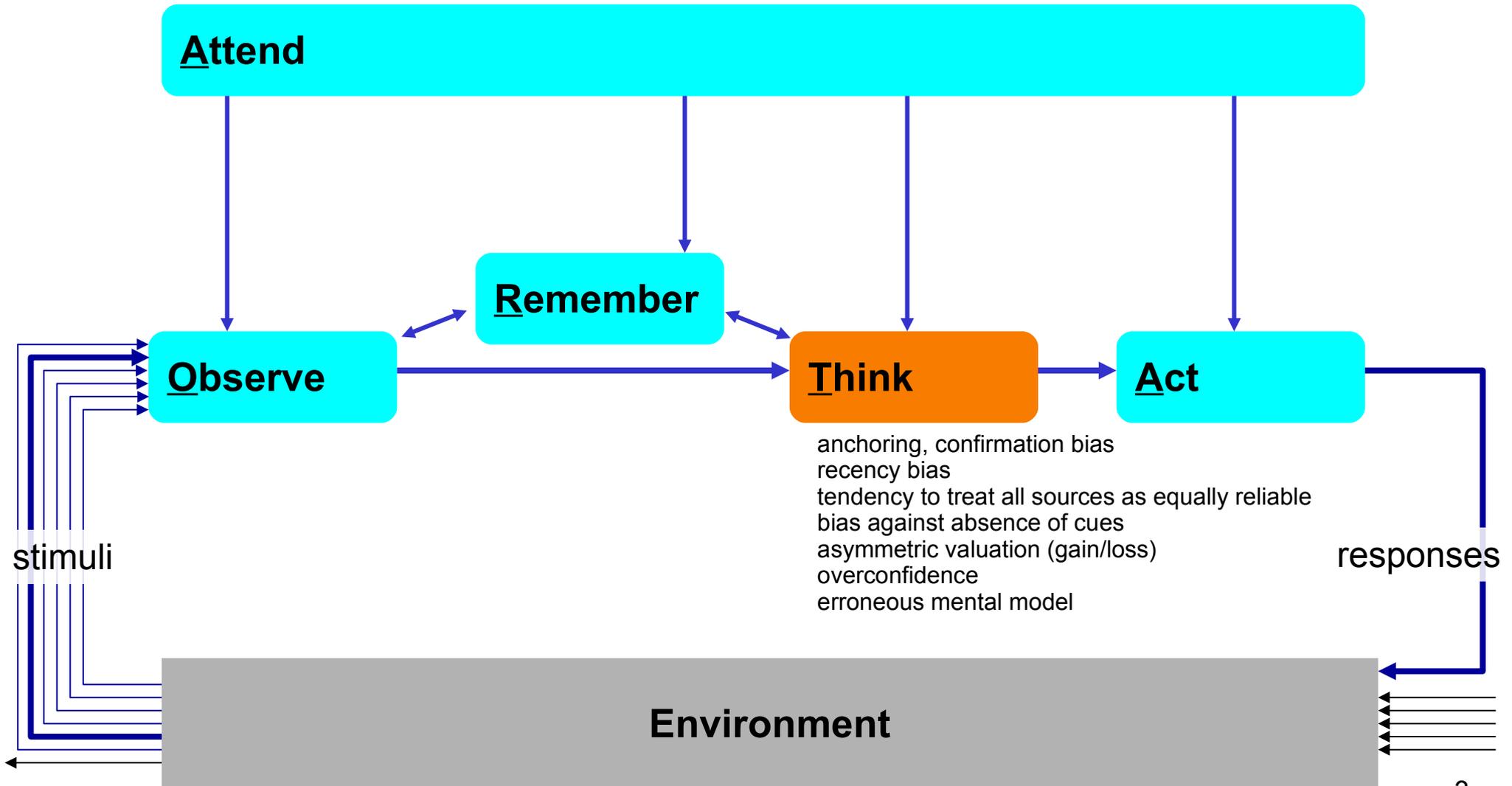
## Decision Making

# Think

(Decision Making, Problem Solving, Trouble-shooting, ...)



# Some Common Human Decision Making,..., Fallibilities



# Decision Making

- Choice among hypotheses/alternatives (known or to-be-generated)
- Conscious (attentive, not pre-attentive)
- Some information available, but not complete
- Time frame: seconds to hours
- Uncertainty about cues, outcomes
- Risk
  - potential that something unwanted or harmful may occur
  - = f (uncertainty, consequences)
- Phases
  1. Receive and use cues
  2. Generate hypotheses and choose
  3. Select action to implement choice

# Decision Making Models

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- Normative Decision Models
  - Utility = subjective value, “goodness”
  - Multi-attribute Decision Making Theory
    - e.g., choose a printer

# MCDM Example: Selecting a Printer

## Inkjet Printer Comparison Multi-Criterion Decision Matrix

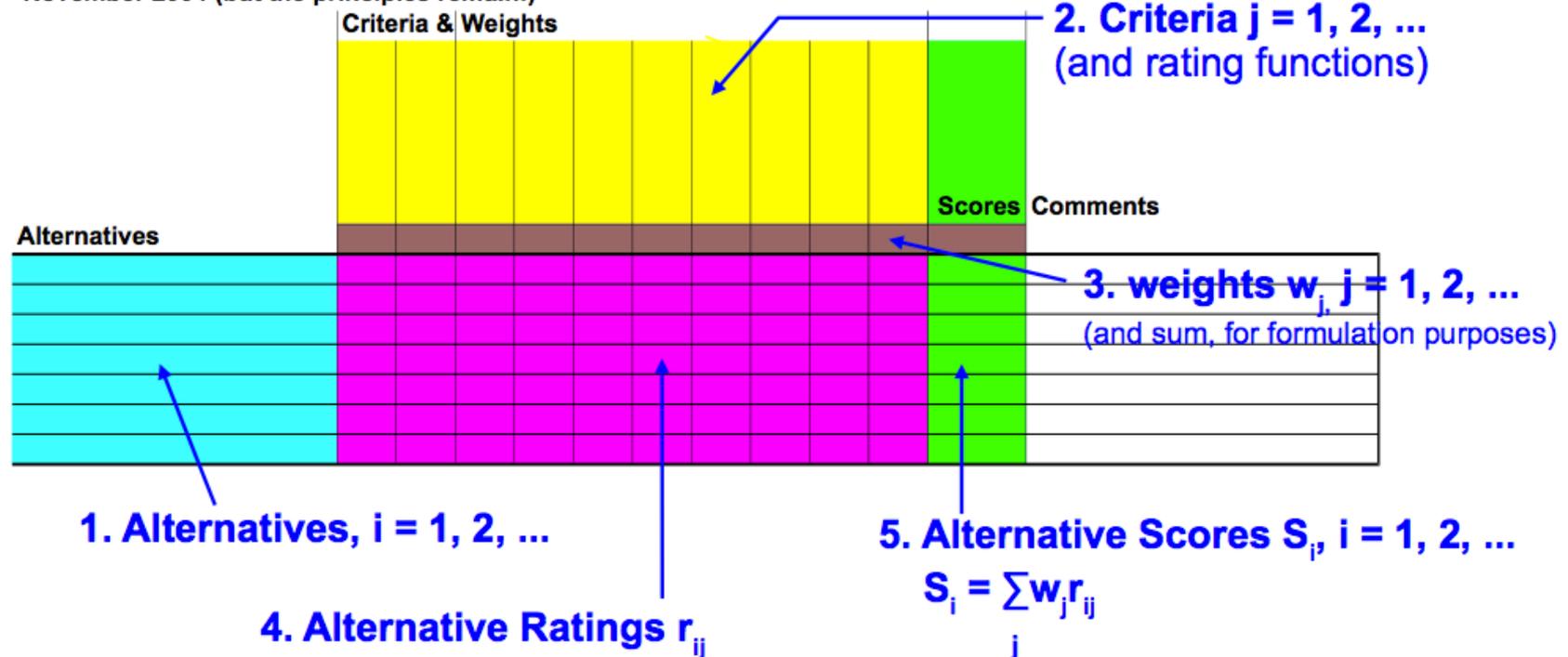
'November 2004 (but the principles remain!)

	Criteria & Weights										Scores	Comments
Alternatives												

# MCDM Example (2)

## Inkjet Printer Comparison Multi-Criterion Decision Matrix

'November 2004 (but the principles remain!)



# MCDM Example (3)

## Inkjet Printer Comparison Multi-Criterion Decision Matrix

'November 2004 (but the principles remain!)

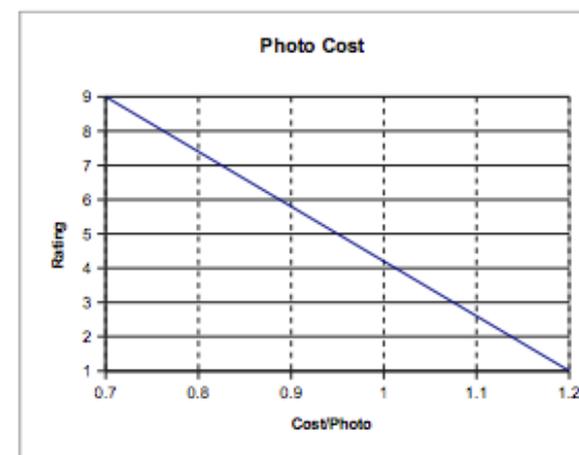
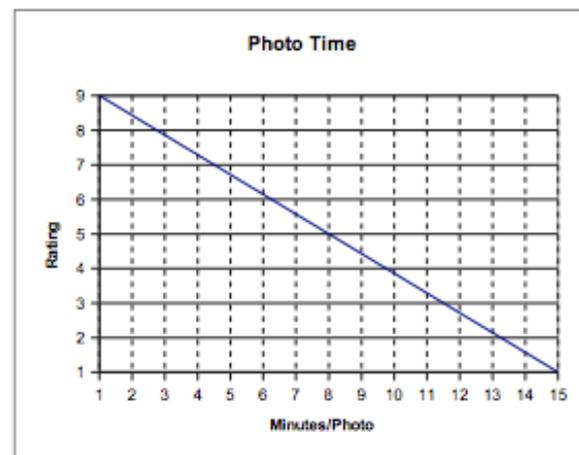
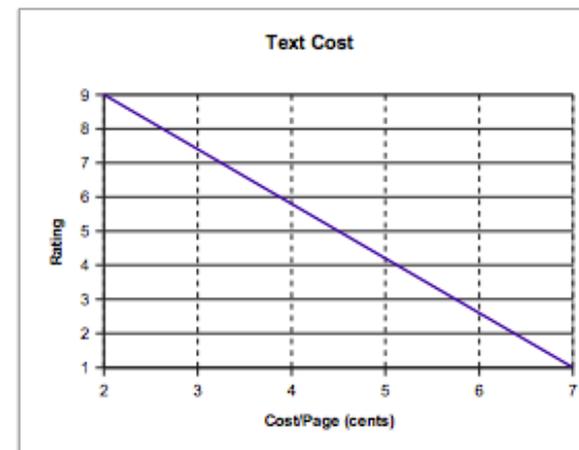
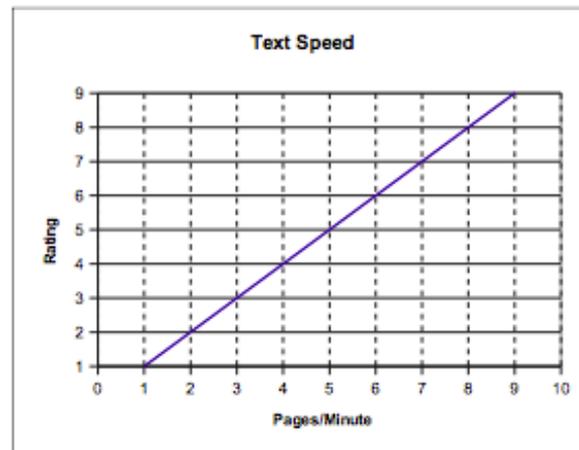
Alternatives	Criteria & Weights											Scores	Comments
	Text Quality	Text Speed	Text Cost	Photo Quality	Photo Time	Photo Cost	Graphics Quality	Extra Features	Usability	Printer Cost			
	1	1	1	1	1	1	1	1	1	1	1	10	
HP Deskjet 995c													\$250 @ Staples
HP Deskjet 6127													\$250 @ OfficeMax
Epson Stylus Photo R800													\$400 @ OfficeMax
Epson Stylus Photo R200													\$100 @ Staples & OfficeMax
Canon Photo Printer i900D													\$240 @ Staples
Canon Photo Printer i860													\$150 @ OfficeMax

# MCDM Example (4)

## MCDM Decision Criteria and Rating Functions

Text Quality, Photo Quality, Graphics Quality, Usability

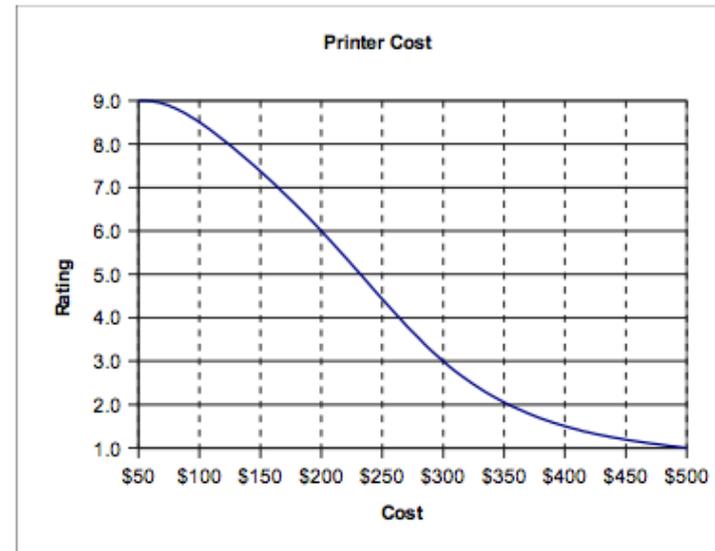
Description	Rating
Excellent	9
Very Good	7
Good	5
Fair	3
Poor	1



# MCDM Example (5)

**Features** (LCD viewer, Individual color tanks, Swap black/photo ink, Memory cards, Prints from camera, Borderless photos)

Features	Rating
$\geq 4$	9
3	7
2	5
1	3
0	1



# MCDM Example (6)

## Inkjet Printer Comparison Multi-Criterion Decision Matrix

'November 2004 (but the principles remain!)

Alternatives	Criteria & Weights										Scores	Comments
	Text Quality	Text Speed	Text Cost	Photo Quality	Photo Time	Photo Cost	Graphics Quality	Extra Features	Usability	Printer Cost		
	20	5	10	25	5	5	10	5	10	5	100	
HP Deskjet 995c	9	5	5	7	5	7	9	3	9	4	705	\$250 @ Staples
HP Deskjet 6127	7	7	5	9	3	7	9	1	9	4	705	\$250 @ OfficeMax
Epson Stylus Photo R800	9	3	7	9	6	1	3	5	7	2	660	\$400 @ OfficeMax
Epson Stylus Photo R200	5	3	6	9	3	6	5	5	7	9	635	\$100 @ Staples & OfficeMax
Canon Photo Printer i900D	7	3	5	9	6	6	5	9	8	5	690	\$240 @ Staples
Canon Photo Printer i860	9	9	8	9	6	7	5	7	8	7	795	\$150 @ OfficeMax

Data adapted from *Consumer Reports*, September 2004, p. 27

# Decision Making Models

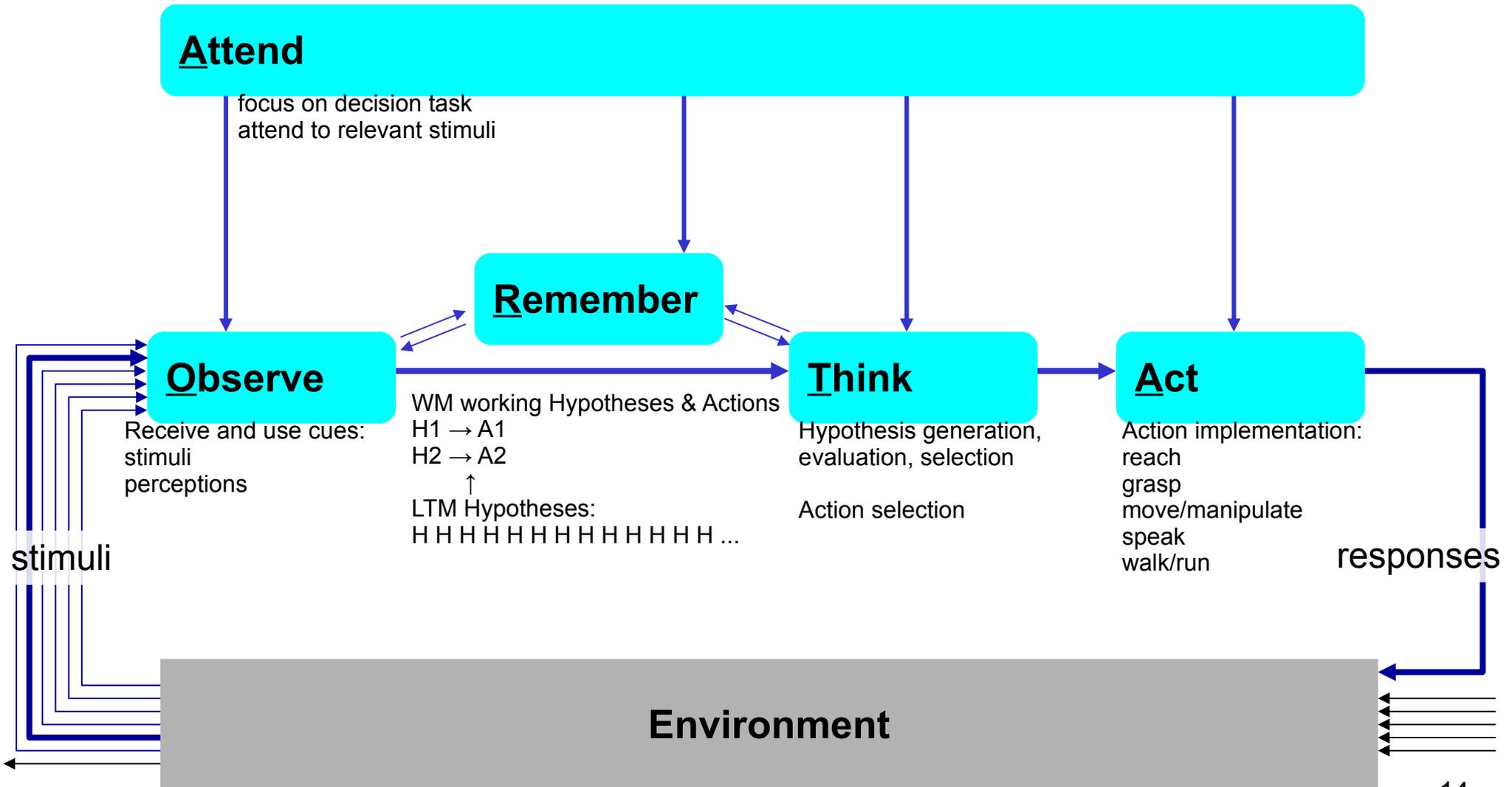
- Normative Decision Models
    - Utility = subjective value, “goodness”
    - Multi-attribute Decision Making Theory
      - e.g., choose a printer
    - Expected Value Theory
    - Subjective Expected Utility
  - Descriptive Decision Models
    - Satisficing
    - Naturalistic decision making (complex, dynamic, often intuitive)
- $$\max \forall i E(x_i) = p_i \text{val}(x_i)$$
- $$\max \forall i U(x_i) = p_i \text{util}(x_i)$$

# Heuristics and Biases

- Information Processing Limits in Decision Making: See Fig. 7.2, p.163, AORTA/Stage model (next slide)
  1. Heuristics and Biases in Receiving and Using Cues
  2. Heuristics and Biases in Hypothesis Generation, Evaluation, and Selection
  3. Heuristics and Biases in Action Selection

# Information Processing Model of Decision Making

after Wickens, Lee, Liu, and Gordon Becker (2004)



# Heuristics and Biases

- Information Processing Limits in Decision Making: See Fig. 7.2, p.163, AORTA/Stage model.
  1. Heuristics and Biases in Receiving and Using Cues
  2. Heuristics and Biases in Hypothesis Generation, Evaluation, and Selection
  3. Heuristics and Biases in Action Selection

# Heuristics and Biases in Receiving and Using Cues

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- Attention to limited number of cues
- Cue primacy and anchoring
- Inattention to later cues
- Cue salience
- Overweighting of unreliable cues

# Heuristics and Biases in Hypothesis Generation, Evaluation, and Selection

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- Generation of a limited number of hypotheses
- Availability heuristic
- Representativeness heuristic
- Overconfidence
- Cognitive tunneling (fixation)
- Anchoring and confirmation bias

# Anchoring, Confirmation Bias

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... The human understanding, when any proposition has been once laid down (either from general admission and belief, or from the pleasure it affords), forces everything else to add fresh support and confirmation; and although most cogent and abundant instances may exist to the contrary, yet either does not observe or despises them, or gets rid of and rejects them by some distinction, with violent and injurious prejudice, rather than sacrifice the authority of its first conclusions. ...

Francis Bacon

*Novum Organum*, 1620

# Heuristics and Biases in Action Selection

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- Retrieve a small number of actions
- Availability heuristic for actions
- Availability of possible outcomes
- Framing effect / framing bias
  - People tend to incur greater risks to avoid losses
  - Sunk cost bias (“throw good money after bad”)
  - To discourage risky behavior\*, frame decisions WRT gains

\* not always best!

# Two Opportunities

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## 1. Gamble?

- 10% chance to win \$95
- 90% to lose \$5

# Two Opportunities

---

## 2. \$5 lottery?

- 10% chance to win \$100
- 90% chance to win nothing

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# Two Opportunities

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In study by Kahneman & Tversky<sup>1</sup>, more picked 2:

## **Framing Effect**

<sup>1</sup> Kahneman, D. (2011). *Thinking, Fast and Slow*. New York: Farrar, Straus, and Giroux, 364.

# Framing Effect Example (experiment)<sup>1</sup>

- US preparing for disease outbreak
- 600 expected to die
- Two alternative programs proposed:

## Alternatives framed as gains:

A: P (save 200 people) = 1

or

B: P (save 600 people) =  $\frac{1}{3}$

P (save none) =  $\frac{2}{3}$

## Alternatives framed as losses:

C: P (400 die) = 1

or

D: P (none die) =  $\frac{1}{3}$

P (600 die) =  $\frac{2}{3}$

<sup>1</sup> Tversky, A. & D. Kahneman (1981). The framing of decisions and the psychology of choice, *Science*, 211 (30), 453-458.

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P (save none) =  $\frac{2}{3}$

## Alternatives framed as losses:

C: P (400 die) = 1

or

D: P (none die) =  $\frac{1}{3}$

P (600 die) =  $\frac{2}{3}$

Of 152 participants:

72% picked A

28% picked B

Of 155 different participants:

22% picked C

78% picked D

<sup>1</sup> Tversky, A. & D. Kahneman (1981). The framing of decisions and the psychology of choice, *Science*, 211 (30), 453-458.

# Benefits of Heuristics, Costs of Biases

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- Heuristics simplify decision making
- Work most of time ...
- ... but not all: lead to systematic biases\*

\*bias: tendency to decide one way or the other

# Dependency of Decision Making on Decision Context

- Most people make pretty good decisions most of the time: heuristics work.
- Automatic vs control processing
- Skill-, Rule-, and Knowledge-Based Behavior
  - See Fig. 7.3, p. 171
  - Signals → Skill-based Behavior [automatic, fast]
  - Signs → Rule-based Behavior [IF condition Then action]
  - Symbolic knowledge (symbols) → Knowledge-based Behavior [attention-, WM-intensive, slow]
  - Personal driving example
- Recognition-Primed Decision Making
  - Familiar pattern → standard response
  - NB: Experts can recognize subtle differences in a pattern that make it novel & therefore require care & reason

# Factors Affecting Decision Making Performance

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- See Fig. 7.4, p. 175
- Decision Making Factors/Limitations
  - Inadequate cue integration
  - Inadequate / poor quality knowledge
  - Tendency to adopt single course of action
  - Incorrect/incomplete mental model
  - Working memory limits
  - Poor awareness of changing situation (poor SA)
  - Inadequate metacognition
  - Poor feedback WRT past decisions

# Improving Decision Making

- Task redesign
  - Better than trying to change person
- Decision Support Systems
  - Displays
  - Flowcharts
  - Decision matrices (MCDM)
  - Spreadsheets
  - Simulations
- Training
  - Anti-bias training
  - Metacognition training
  - Development of accurate/useful mental models
  - Perception/pattern recognition training
  - Relevant cue training
  - **Limitations to training**