

**Cognition  
Psychology 215  
Emory University  
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**Topic 10: Thought  
Lecture 10a: Decision making**

## Overview of thought topics

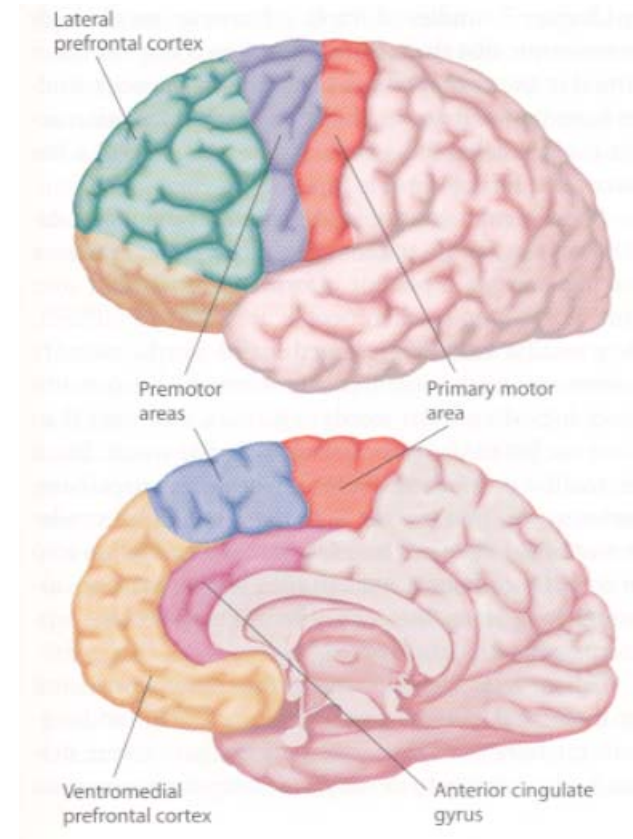
- a rough definition of thought
- classic types of thought
- the frontal lobes play central roles in thinking
  - however the posterior sensory-motor areas are also likely to be involved

# Roles of the frontal lobes in thought

Gazzaniga, Ivry, and Mangun (1998)

- three regions of the frontal lobes central to thought

- functions of the frontal lobes



# Important distinctions in thought phenomena

- **normative vs. descriptive**

- **normative:**

- **descriptive:**

- **formal vs. domain-specific**

- **formal:**

- **domain specific:**

- **algorithm vs. heuristic**

- **algorithm:**

- 

- **heuristic:**

- **science vs. human reasoning**

# Decision making: The normative formalism of expected utility theory

- **a normative way to make a decision from economics**

- an agent has to decide between several choices,  $C_i$
- each choice has an expected utility (EU) that depends on:
  1. its possible outcomes,  $O_i$
  2. the probability of the outcome occurring given that the choice is made,  $P(O_i|C_i)$
  3. the subjective utility of each possible outcome,  $U(O_i)$

- **expected utility theory**

- for each choice, multiply the probability and utility for each outcome, and sum across the products
- pick the choice with the highest sum

$$EU(C_1) = P(O_1|C_1) U(O_1) + P(O_2|C_1) U(O_2) + P(O_3|C_1) U(O_3) + \dots P(O_n|C_1) U(O_n)$$

$$EU(C_2) = P(O_1|C_2) U(O_1) + P(O_2|C_2) U(O_2) + P(O_3|C_2) U(O_3) + \dots P(O_n|C_2) U(O_n) \dots$$

$$EU(C_m) = P(O_1|C_m) U(O_1) + P(O_2|C_m) U(O_2) + P(O_3|C_m) U(O_3) + \dots P(O_n|C_m) U(O_n)$$

## **Violations of expected utility theory**

- **very roughly speaking, people follow expected utility theory**
  
- **however, there are numerous problems for expected utility theory**
  
- **three general classes of problems**
  1. violations of optimal integration in the equation
  2. complications arising for the utilities in the equation
  3. violations of the probabilities in the equation
  
- **for the decision making problems to follow, write your responses on today's in-class exercise sheet**

## Violations of optimal integration in the expected utility equation The Allais (1953) paradox (Medin & Ross, 1997)

**Which of the following two choices do you prefer?**

- **CHOICE 1:** 100% chance of winning \$1,000  
0% chance of winning \$0
- **CHOICE 2:** 89% chance of winning \$1,000  
10% chance of winning \$5,000  
1% chance of winning \$0

**Which of the following two choices do you prefer?**

- **CHOICE 3:** 11% chance of winning \$1,000  
89% chance of winning \$0
- **CHOICE 4:** 10% chance of winning \$5,000  
90% chance of winning \$0

• **the expected utility prediction**

- the two questions are formally identical
- choices 3 and 4 were obtained by subtracting an 89% chance of winning \$1,000 from choices 1 and 2 each
- because expected utility is additive
  - the relative values of choices 1 and 2 must be the same as the relative values of choices 3 and 4
  - if you preferred 1 over 2, you should have also preferred 3 over 4

• **the violation**

- most people prefer 1 over 2, but 4 over 3

• **the explanation**

- people like the certainty of choice 1, 100%
- when there is no certainty, the higher amount (\$5,000) is more attractive, and the slightly lower probability (10%) is ignored
- the 99% chance of winning in 2 is missed

# Violations of optimal integration in the expected utility equation Tversky and Kahneman (1981)



Tversky

Kahneman

**In an epidemic, which of the following two choices do you prefer?**

- **CHOICE 1:** 80% chance of losing 100 lives
- **CHOICE 2:** 100% chance of losing 75 lives

**In an epidemic, which of the following two choices do you prefer?**

- **CHOICE 3:** 8% chance of losing 100 lives
- **CHOICE 4:** 10% chance of losing 75 lives

## • the expected utility prediction

- the two questions are formally identical
- choices 3 and 4 were obtained by reducing the probabilities in choices 1 and 2 each by a factor of 10
- because expected utility is additive
  - the relative values of choices 1 and 2 must be the same as the relative values of choices 3 and 4
  - if you preferred 1 over 2, you should have also preferred 3 over 4

## • the violation

- most people prefer 1 over 2, but 4 over 3

## • the explanation

- people don't like the certainty of choice 2, 100%
- when there is no certainty, the lower lives lost (75) is more attractive, and the slightly higher probability (10%) is ignored

# Complications with utilities in the expected utility equation :

## Framing effects

Shafir (1993)

$$EU(C_1) = P(O_1|C_1) U(O_1) + \dots$$

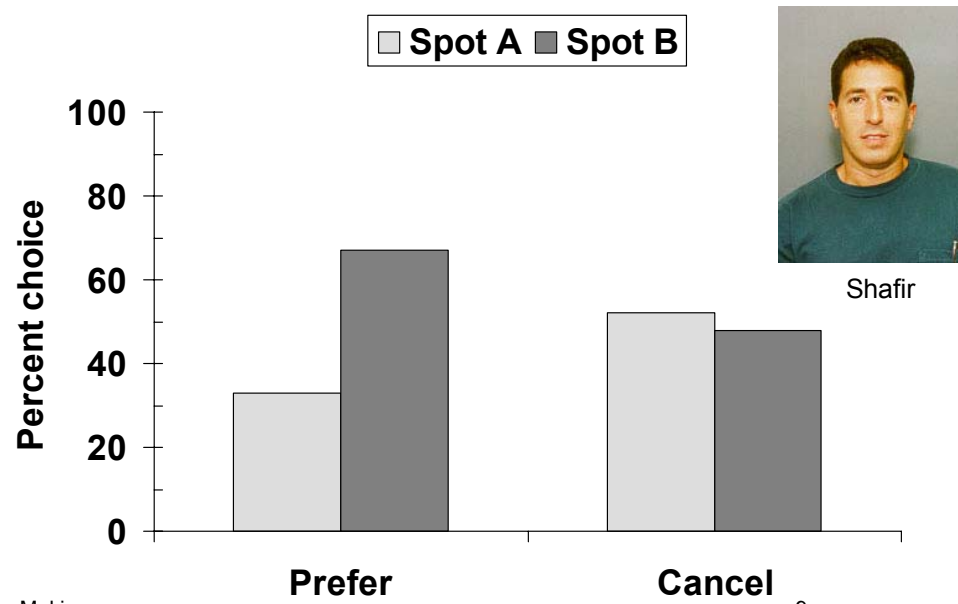
Imagine that you are planning a week vacation in a warm spot over spring break. You currently have two options that are reasonably priced. The travel brochure gives only a limited amount of information about two options. Given the information available, **which vacation spot would you prefer.**

Imagine that your are planning a week vacation in a warm spot over spring break. You currently have two options that are reasonably priced, **but you can no longer retain your reservation at both.** The travel brochure gives only a limited amount of information about two options. Given the information available, **which reservation do you decide to cancel.**

**Vacation Spot A**  
 average weather  
 average beaches  
 medium quality hotel  
 medium temperature water  
 average nightlife

**Vacation Spot B**  
 lots of sunshine  
 gorgeous beaches  
 ultra-modern hotel  
 very cold water  
 very strong winds  
 no nightlife

- **prediction from expected utility theory**
  - the relative preferences for Spots A and B should stay constant for prefer and cancel instructions
    - because the probabilities and utilities do not change
- **but the relative preferences change**
  - Prefer: B > A                      Cancel: A = B
  - all of A's features are average
    - all of Bs features are extremely positive or negative
  - the utilities change with instructional focus in a complex way
    - reflects utility of positive features higher for prefer
    - and utility of negative features lower for cancel



**Complications with utilities in the expected utility equation:  
Losses loom larger than gains  
Kahneman and Tversky (1979)**

**Which choice do you prefer?**

**Choice A:** You take a bet in which a fair coin is tossed.  
If the toss comes up heads, you win \$10.  
If the toss comes up tails, you lose \$10.

**Choice B:** You don't take the bet.

- **prediction from expected utility theory**
  - there should be no strong preference for either choice
  - because each choice has an average expected value of \$0
- **results**
  - people strongly prefer Choice B
- **losses loom larger than gains**
  - a single monetary value has different utilities depending on whether it's a loss or gain
  - losing a particular amount of money is seen as more of a loss than winning it is seen as a gain
  - again, utilities vary with the context in which they are perceived

## Normatively estimating the probabilities in the expected utility equation: Bayes' Theorem

- using the expected utility equation requires the estimation of probabilities
- the normative way to estimate probabilities is with Bayes' Theorem

$$P(O|E) = \frac{P(E|O) P(O)}{P(E)}$$

$P(O|E)$  = probability of the outcome given the present evidence that the outcome will occur

$P(E|O)$  = probability that the evidence would be present if the outcome occurred

$P(O)$  = the base rate of the outcome occurring

$P(E)$  = the base rate of the evidence being present

- **two basic sources of prediction in Bayes' Theorem**

$P(O)$  the base rate

$P(E|O)$  the representativeness of the evidence

- **example**

- predicting whether it will rain this evening
  - the base rate,  $P(O)$  = how often does it rain in the evening
  - representativeness,  $P(E|O)$  = when it rains, how much does the sky look like it does today beforehand

## Violations of estimating probabilities normatively: Representativeness Kahneman & Tversky (1972), Tversky and Kahneman (1983)

Imagine that you meet a new student dressed in black leather with a blue mohawk, piercing, and tattoos. What is the probability that this student is majoring in the arts, as opposed to history, biology, business, etc?

- **subjects tend to produce very high probabilities that this student is an arts major.**
  - subjects focus on representativeness,  $P(E|O)$ 
    - if someone is actually known to be an arts major (O), they often have this appearance (E)
  - subjects ignore the base rates,  $P(O)$ 
    - arts majors are rare at most colleges (i.e., other majors are much more common)
  - ideally, base rates should be considered as much as the representativeness of the current evidence
    - thus, the estimate based on representativeness should be lowered considerably in this example

$$P(O|E) = \frac{P(E|O) P(O)}{P(E)}$$

$P(O|E)$  = probability of the outcome given the present evidence that the outcome will occur

$P(E|O)$  = probability that the evidence would be present if the outcome occurred

$P(O)$  = the base rate of the outcome occurring

$P(E)$  = the base rate of the evidence being present

# Violations of estimating probabilities normatively: Representativeness in the conjunction fallacy Tversky and Kahneman (1983)

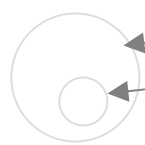
**Which is more likely?**

**Choice A:** A rancher from Wyoming driving a Toyota?

**Choice B:** A rancher from Wyoming driving a Toyota truck?

**• results**

- subjects overwhelmingly select: “A rancher from Wyoming driving a Toyota truck.”
- however, the correct answer is: “A rancher from Wyoming driving a Toyota.”



“A rancher from Wyoming driving a Toyota” includes the smaller set  
 “A rancher from Wyoming driving a Toyota truck.”

**• explanation of the error**

- ranchers driving Toyota trucks are similar to knowledge in memory
  - ranchers driving Toyotas are not
- in terms of Bayes’ Theorem:
  - there are 2 possible outcomes( O): (1) Toyota, (2)Toyota truck
  - the evidence (E) is: A rancher from Wyoming
  - for P(E|O): P(A rancher from Wyoming | Toyota truck) > P(A rancher from Wyoming | Toyota)
  - for P(O): P(Toyota) > P(Toyota truck)
  - subjects allow P(E|O) to dominate P(O)

$$P(O|E) = \frac{P(E|O) P(O)}{P(E)}$$

# Violations of estimating probabilities normatively: Availability Tversky and Kahneman (1973)

**Which type of four-letter word has more members?**

Words that begin with an R? R \_ \_ \_

Words that have R in the third position. \_ \_ R \_

• **correct answer:**

\_ \_ R \_ words are more common than R \_ \_ \_ words

• **results**

- 69% of subjects believed that there are more R \_ \_ \_ words
- (averaged over 5 letters for which more words begin with the letter in the 3rd position than the 1st)

• **explanation**

- it's easier to generate R \_ \_ \_ words than \_ \_ R \_ words from memory
  - i.e., **AVAILABILITY**
- people estimate probabilities based on what they can retrieve
  - the easier it is to retrieve instances of something, the higher its estimated probability
- often memory mechanisms do track frequency well
  - sometimes, however, they produce biases

# Violations of estimating probabilities normatively: Availability Tversky and Kahneman (1973)

- **laboratory demonstration of availability**
- **learning**
  - subjects studied the names of 19 famous women and 20 names of less famous men
- **testing**
  - one half of the subjects were asked whether the list contained more famous men or women
  - one half of the subjects recalled as many names as they could
- **results**
  - 80% of the frequency estimate subjects believed that the list contained more women than men
  - the memory subjects recalled 65% of the womens' names, and 42% of the mens' names
- **explanation**
  - the famous womens' names were easier to recall than the less famous mens' names
  - frequency subjects based their frequency estimates on this availability
    - and therefore erred in judging whether a woman's or man's name was more likely

## Violations of estimating probabilities normatively: Anchoring Tversky and Kahneman (1974)

The left side of the class:  
Estimate the value of the following product:

$$1 \times 2 \times 3 \times 4 \times 5 \times 6 \times 7 \times 8$$

The right side of the class:  
Estimate the value of the following product:

$$8 \times 7 \times 6 \times 5 \times 4 \times 3 \times 2 \times 1$$

### • results

- the median estimate of the subjects for the product on the left was 512
- the median estimate of the subjects for the product on the right was 2,250
- the correct answer for both is 40,320

### • explanation

- the first number encountered anchors the estimate
  - encountering a small initial number produces a low anchor and subsequent estimate
  - encountering a large initial number produces a higher anchor and subsequent estimate
- another bias in estimation

### • application

- sales people capitalize on this all the time
  - set a high price and then come down
- buyers do the opposite
  - set a low price and then come up

## The simulation heuristic Kahneman and Tversky (1982)

Mr. Crane and Mr. Tees were scheduled to leave the airport on different flights, at the same time. They traveled from town together in the same limousine, were caught in traffic jam, and arrived at the airport 30 minutes after the scheduled departure time 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 15 minutes ago.

Who is more upset?

Mr. Crane	4%
Mr. Tees	96%

• **explanation**

- the situation of the two travelers is identical
  - they both missed a plane, and are now in the same situation
- but Mr. Tees can imagine that it was more possible for him to make his plane than can Mr. Crane
  - where the imagined scenario is a simulation

• **simulation seems to be extensively used in decision making (examples from K&T)**

- Imagine that two friends who don't know each other meet. How will they get along?
- If war breaks out in the Middle East, what are some likely consequences?
- If Hitler had developed the atom bomb in February 1945, would WW II have ended differently?

## Probabilities vs. frequencies Gigerenzer (1991)



Gigerenzer

- **much Tversky and Kahneman work illustrates biases in probability estimates**
  - e.g., the classic Kahneman and Tversky (1972) paper on representativeness
  - perhaps probability is not a natural sort of thing for people to estimate
  - the concept of probability was only introduced in the 19th century
    - although more intuitive constructs such as plausibility and confidence have been around forever
- **perhaps frequency is a more intuitive construct than probability**
  - rather than asking someone the probability that a student is an arts major, ask them to make the following estimate:

Imagine 100 Emory students.

Estimate the number that wear black leather, have a blue mohawk, piercing, and tattoos, and are arts majors?

- under these conditions, subjects behave much more normatively
- **conclusions**
  - transforming questions from probabilities to frequencies often improves performance substantially
    - Tversky and Kahneman actually pointed this out in much of their earlier work
  - nevertheless, people frequently use constructs such as probability, plausibility, and confidence
    - thus, it's important to understand these constructs and their limitations

## Summary of the literature on decision making

- **normativity**
- **biases**
- **heuristics**
- **content specificity**

## **Preface to the take-home assignment**

- **run an experiment on your own**
  - collect data from your friends
- **compare different problem formats for the representativeness problem**
  - probability format (Kahneman & Tversky, 1972)
  - frequency format (Gigerenzer, 1991)
- **write up a brief report on your experiment and its results**
- **see the assignment on the course web site for the details**

## **Preface to the next in-class exercise**

- **please bring today's lecture notes to the next class**
- **you will need them to do next week's in-class exercise**

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