

# Ch. 12: Reasoning & Decision-making

04/12/07

# Reasoning

- The process by which we construct our own knowledge
  - Going beyond the data

# Two types of reasoning

- Deductive
  - Constructing new information using the rules of logic
  - Symbolic
- Inductive
  - Constructing new information using “the rules of evidence”
  - Probabilistic

# Deductive reasoning

- Syllogisms: Rules for combining premises to reach a conclusion
  - Rules do not necessarily need to be valid!
- Categorical syllogisms: rules involving words like “Some X”, “All X”, “No X”

Premise 1  
Premise 2  
-----  
Conclusion

# Determining validity

All birds are ants  
All ants are green  
All birds know calculus

All dogs are mammals  
Some mammals have hair  
Some dogs have hair

All birds have feathers  
All birds have beaks  
All birds are animals

All birds are ants  
All ants are green  
All birds are green

# Determining validity

- Validity is not the same thing as truth!

# Determining validity

- Principles of validity & truth in syllogisms:
  - The validity of a syllogism is determined only by its form, not its content
  - For a syllogism to be valid, the conclusion must follow for every possible case; if not, it is invalid
  - If the two premises are true, the conclusion of a valid syllogism must be true

# Determining validity

- Can't use truth value to determine validity
- So how can you determine validity?

# Euler circles

1. Draw a circle to represent first category in first premise
2. Draw another circle to represent relationship indicated by first premise
3. Add another circle for the second premise
4. Check to see if conclusion holds in all cases

All birds are animals

All animals eat food

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All birds eat food

# Euler circles

All athletes are people

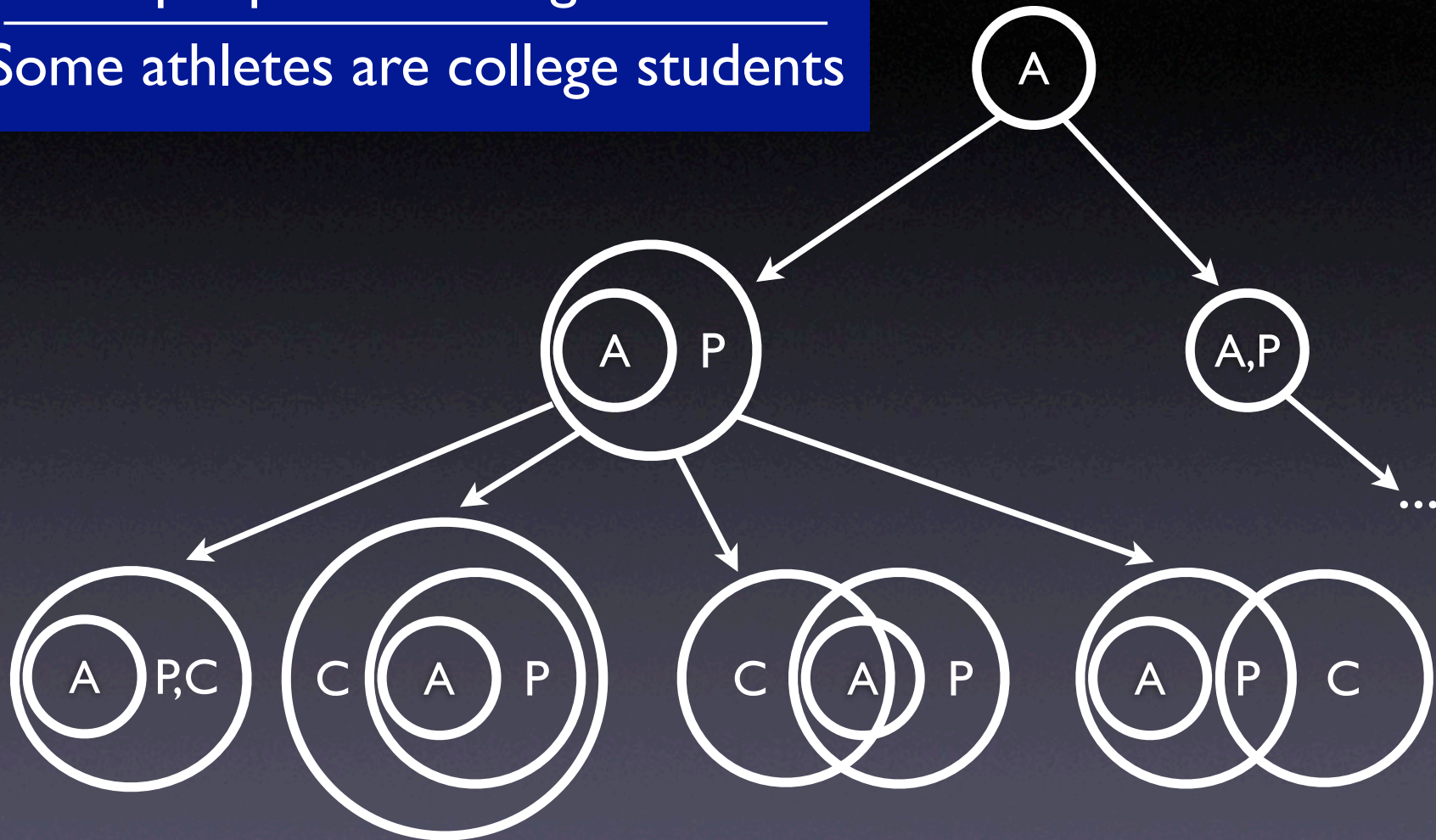
Some people are college students

Some athletes are college students

All athletes are people

Some people are college students

Some athletes are college students



# Normative vs. Descriptive

- Euler circles are one correct way to reason:
  - If applied correctly, will never lead to invalid inference
  - Called 'normative' reasoning
- But how do people *actually* reason?
  - Called 'descriptive' reasoning

# Descriptive approaches

Evaluation approach:      Production approach:

Premise 1  
Premise 2  
-----  
Conclusion

“Is this valid?”

Premise 1  
Premise 2  
-----  
??

“What follows?”

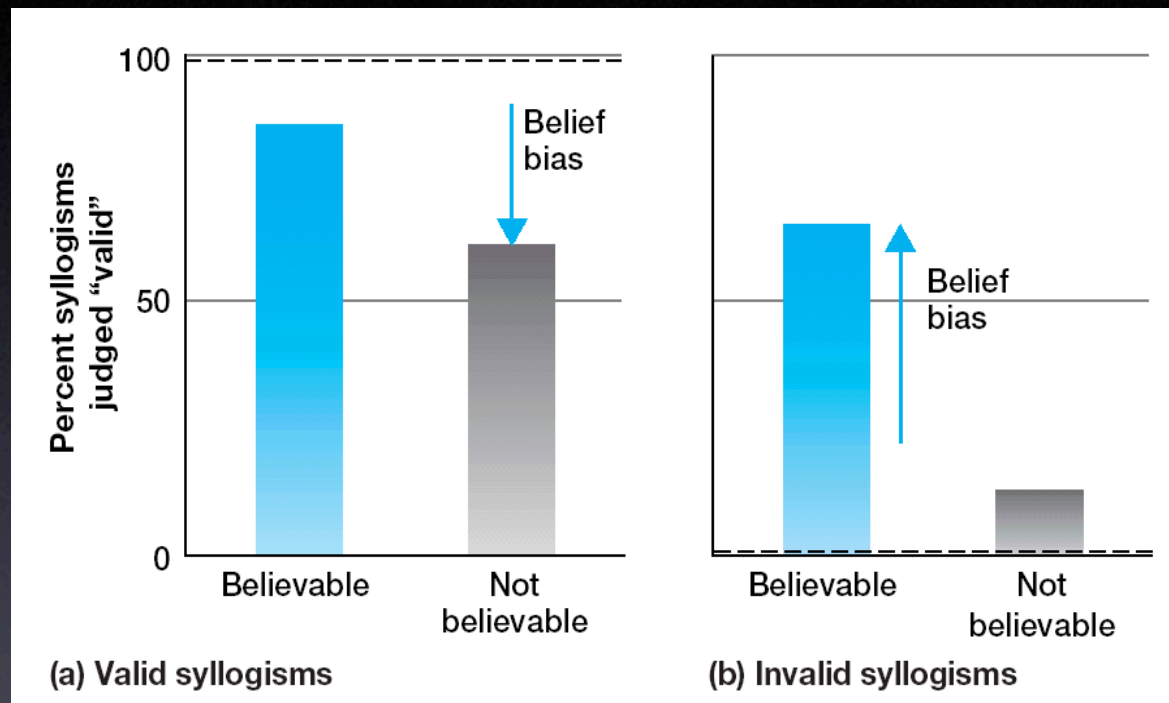
# Descriptive reasoning 101

- People often make mistakes
- Why?
  - Atmosphere effect: Qualifiers (all, some, no) create an overall 'mood' that influences the perceived validity
  - Belief bias: Syllogism more likely to be judged valid if it agrees with a person's beliefs

All of the students are tired  
Some tired people are irritable  
Some of the students are irritable

All of the men are tired  
Some people are women  
Some of the men are women

# Belief bias



The validity of a syllogism is determined only by its form, not its content

# Mental Models

- Mental model: a situation simulated in a person's mind
- Can be used to help determine the validity of information (if it corresponds to the mental model)

None of the artists are beekeepers  
All of the beekeepers are chemists  
Some of the chemists are not artists

None of the artists are beekeepers

All of the beekeepers are chemists

---

Some of the chemists are not artists

#### MODELS OF THE ABC SOCIETY

Susan	Artist		
Roger		Beekeeper	Chemist

**Model 1:** This model supports the conclusion, *None of the artists is a chemist.*

But then we meet Cyrus, and so we create a new model that includes him.

Susan	Artist		
Roger		Beekeeper	Chemist
Cyrus	Artist		Chemist

**Model 2:** This model supports the conclusion, *Some of the chemists are not artists.*

We also meet Natasha.

Natasha			Chemist
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Adding Natasha to Model 2 doesn't change our conclusion.

# Mental models

- Explain how people can reason without having formal education in the rules of logic
- Makes interesting predictions:
  - Syllogisms involving more complex models will lead to more errors

# Culture & reasoning

- Do people in different cultures reason differently?

# Culture & reasoning

In the far north, all bears are white.  
Novaya Zemlya is in the far north.

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Q: What color are the bears there?

A: “You should ask the people who  
have been there and seen them.”

(Schribner, 1977)

# Believability, Culture & Reasoning

Believable

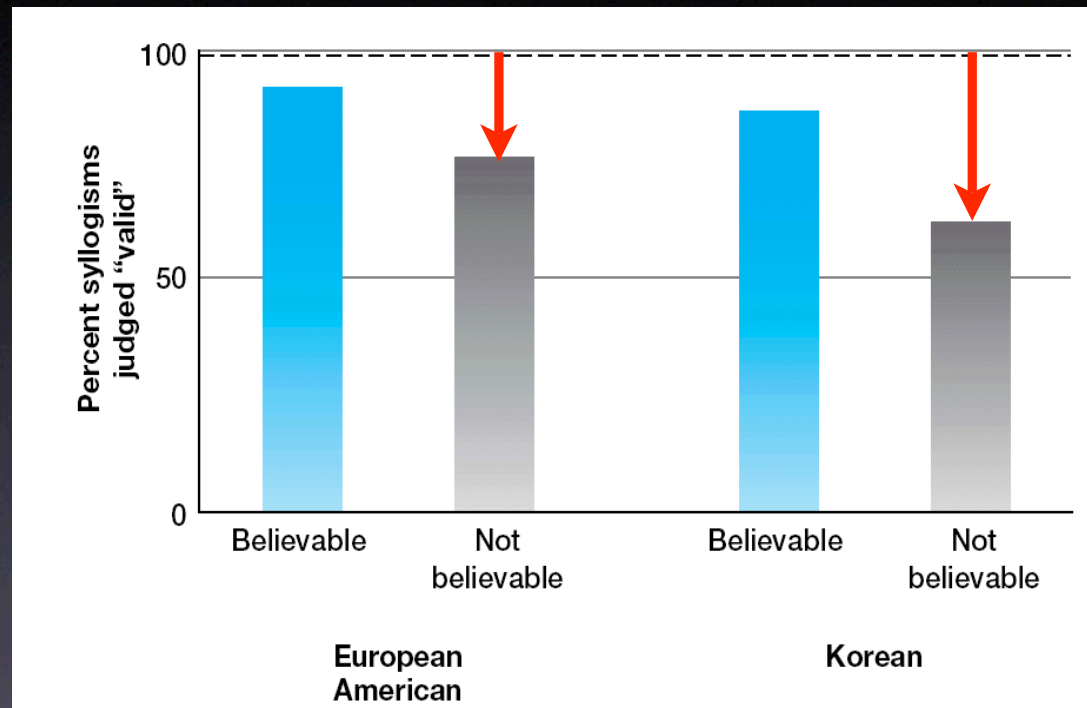
No police dogs are old  
Some highly trained dogs are old  
Some highly trained dogs are not police

Both valid

Not  
believable

All things made from plants are healthy  
Cigarettes are made from plants  
Cigarettes are healthy

# Culture & reasoning



(Norenzayan et al, 2002)

# Conditional reasoning

- Syllogism:
  - Two premises & a conclusion
- Conditional syllogism:
  - First premise has the form “If X then Y”
  - Second premise has the form of either X, Y, Not X, Not Y

# Conditional reasoning

Modus ponens (Valid, 97%)

If I try hard I'll do well in life  
I try hard  
-----  
I'll do well in life

Denying the antecedent (Invalid, 40%)

If I try hard I'll do well in life  
I don't try hard  
-----  
I won't do well in life

If I try hard I'll do well in life  
I didn't do well in life  
-----  
I didn't try hard

Modus tollens (Valid, 60%)

If I try hard I'll do well in life  
I did well in life  
-----  
I tried hard

Affirming the consequent (Invalid, 40%)

# Errors in conditional reasoning

“If one side of the card has a vowel, then the other side has an even number.”



If vowel, then even number.

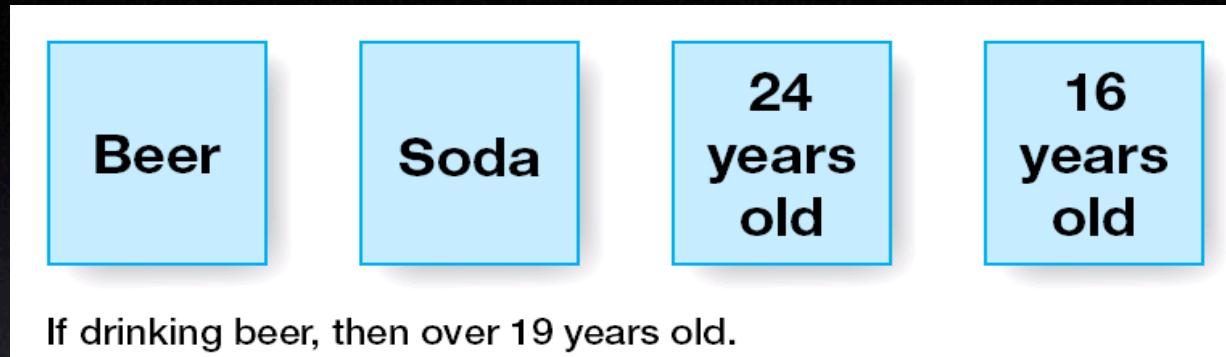
How many cards do you need to turn over to verify the rule?

(Which ones?)

# Errors in conditional reasoning

- Wason card-selection task
  - People suck at it
  - Only ~4% of people come up with right answer
- Key to solving the problem is the falsification principle:
  - To test a rule, it is necessary to look for situations that falsify it

# Understanding conditional reasoning

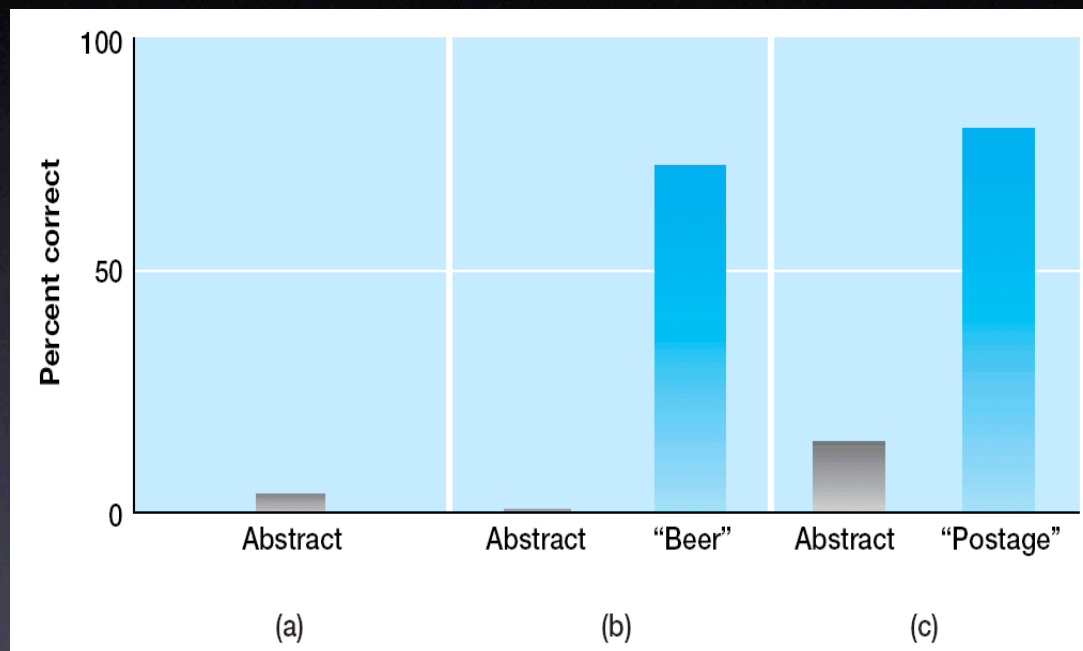


Beer      Soda      24 years old      16 years old

If drinking beer, then over 19 years old.

- People employ pragmatic reasoning schemas
  - One example: Permission schema
  - If person satisfies condition A, they get to carry out action B

# Permission schemas



# Understanding conditional reasoning

- A lot of arbitrary theories of reasoning
- Role of evolution in understanding behavior?
  - Ability to detect cheaters has enormous survival value
  - Social-exchange theory: Important aspect of human behavior is ability to cooperate

# In the end

- Nothing really resolved about the mechanisms behind deductive reasoning
- Evidence presented both for and against every theory that has been proposed (Johnson-Laird, 1999)
- But maybe not too surprising:
  - The human brain really is the most complex entity in the known universe

# Next time

- Quiz on deductive reasoning
  - Through pg. 453 in text
- Lecture on inductive reasoning
  - No assigned reading