# Reasoning

LOGIC, n. The art of thinking and reasoning in strict accordance with the limitations and incapacities of the human misunderstanding. The basic [unit] of logic is the syllogism, consisting of a major and a minor premise and a conclusion -- thus:

_Major Premise_: Sixty men can do a piece of work sixty times as quickly as one man.

_Minor Premise_: One man can dig a posthole in sixty seconds; therefore --

_Conclusion_: Sixty men can dig a posthole in one second.

This may be called the syllogism arithmetical, in which, by combining logic and mathematics, we obtain a double certainty and are twice blessed.

Ambrose Bierce, The Devil's Dictionary

## Remember René Descartes?

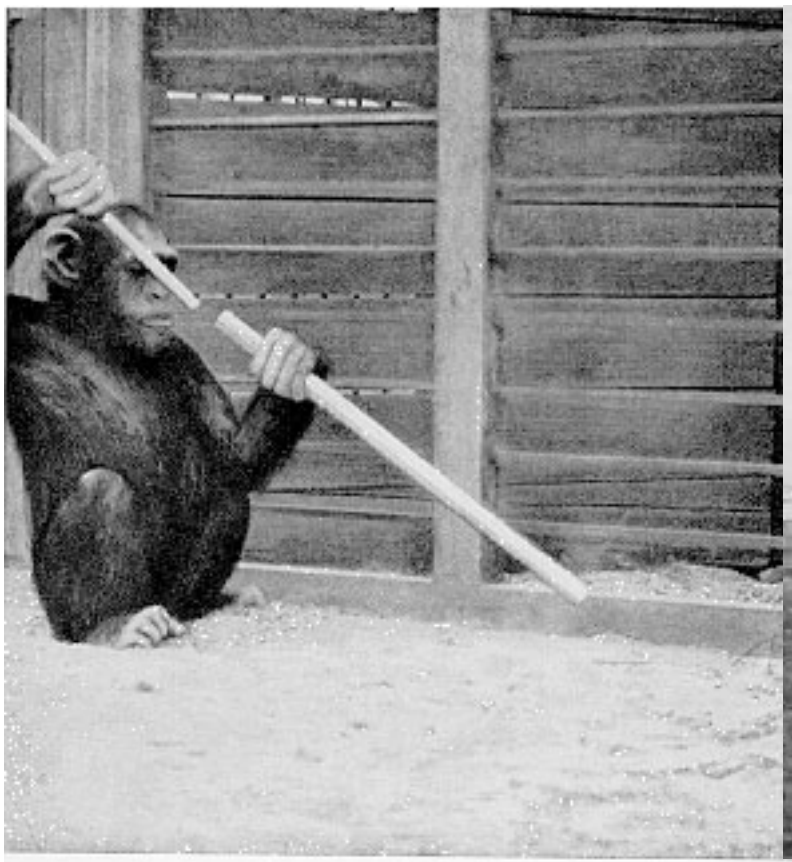
*"The further the mind is taken away from its proper objects – logic and pure reason – the more likely it is to fall into error."*

*"The purpose of philosophy is to direct the mind away from the confusing images of the senses towards the indubitable truths contained within the mind itself."*

Are you a creature of reason?

Reason has frequently been regarded as distinctly human, and not to be found elsewhere in the animal world. However, recent studies in this area show that animals are capable of some rational thinking.

Question to ponder: why value reason so much? birds fly, humans reason. Is it anything other than a weird habit?



# Betty the crow makes and uses a tool

P 20090

Reasoning does not help us in identifying goals or in identifying problems.

Rather, it helps us derive new knowledge from that which we already know

Syllogism

**Premise:** All men are mortal
**Premise:** Socrates is a man

**Conclusion:** Socrates is mortal

**Important**: Reason does not deliver truth. If the premises are nonsense, even the best reasoning will generate nonsense

# Inductive reasoning

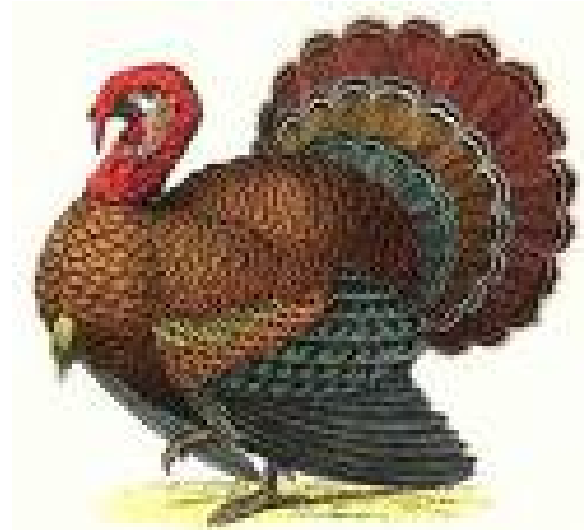
The sun has risen in the east every morning up until now

premise

Therefore the sun will rise in the east tomorrow.

conclusion

# Inductive reasoning



I have been fed every day up until today (23 Dec)

premise

Therefore I will be fed tomorrow (24 Dec)

conclusion

## Inductive reasoning

Conclusion is that which is *probably* the case

. . . even if the premise is 100% factual.

# Deductive Reasoning

'Hard logic'

Conclusion follows from the premises

c.f. the Socrates syllogism...

Again, if the premises are stupid, no amount of deductive reasoning can overcome that.

Do the following enterprises use *inductive* or *deductive* reasoning more?

1) Scientific Inquiry

2) Mathematics

# Inductive reasoning

If the sky is getting very dark and cloudy, it is probably going to rain.

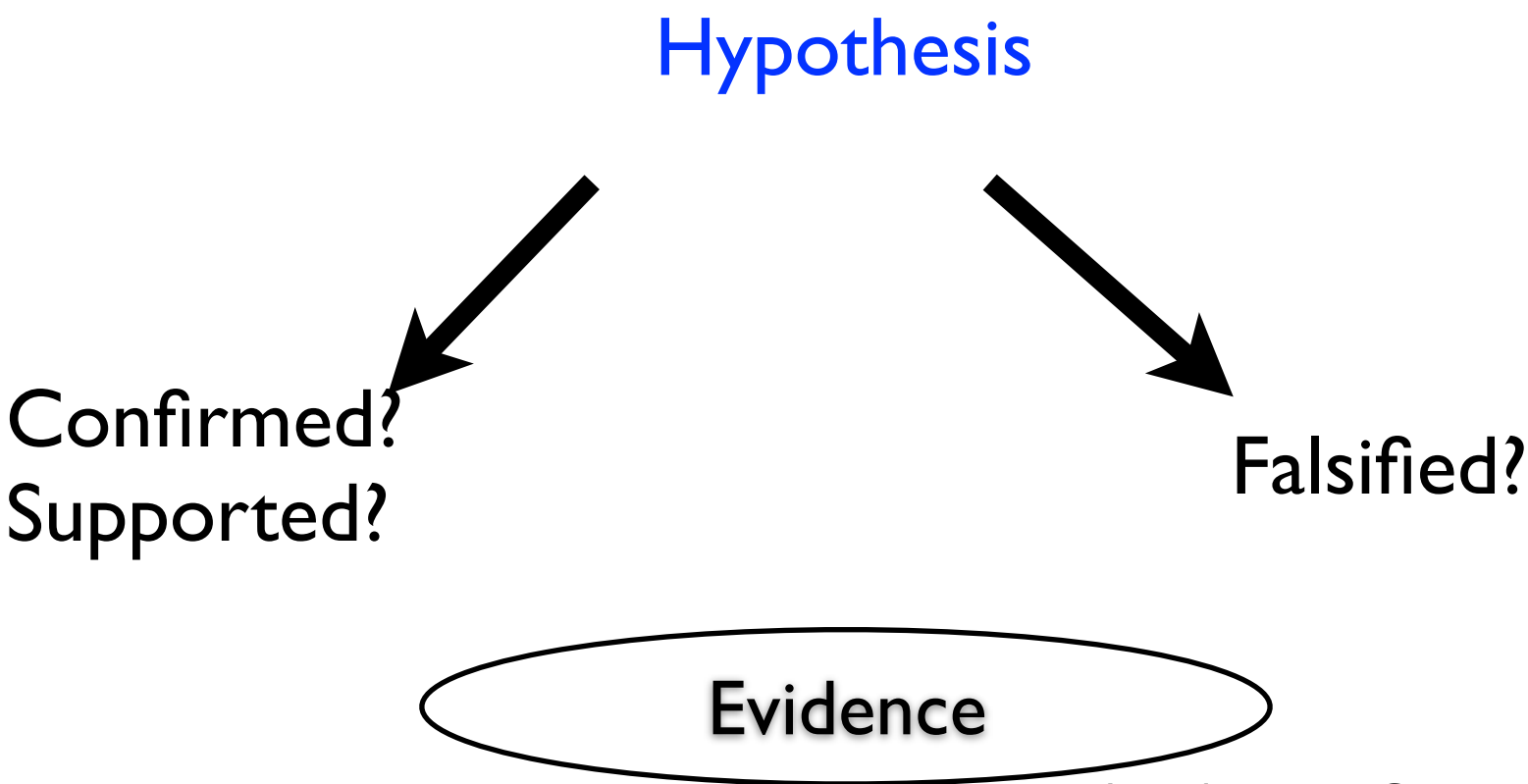
# Inductive reasoning

If I don’t eat something,
I will get hungry.

# Inductive reasoning

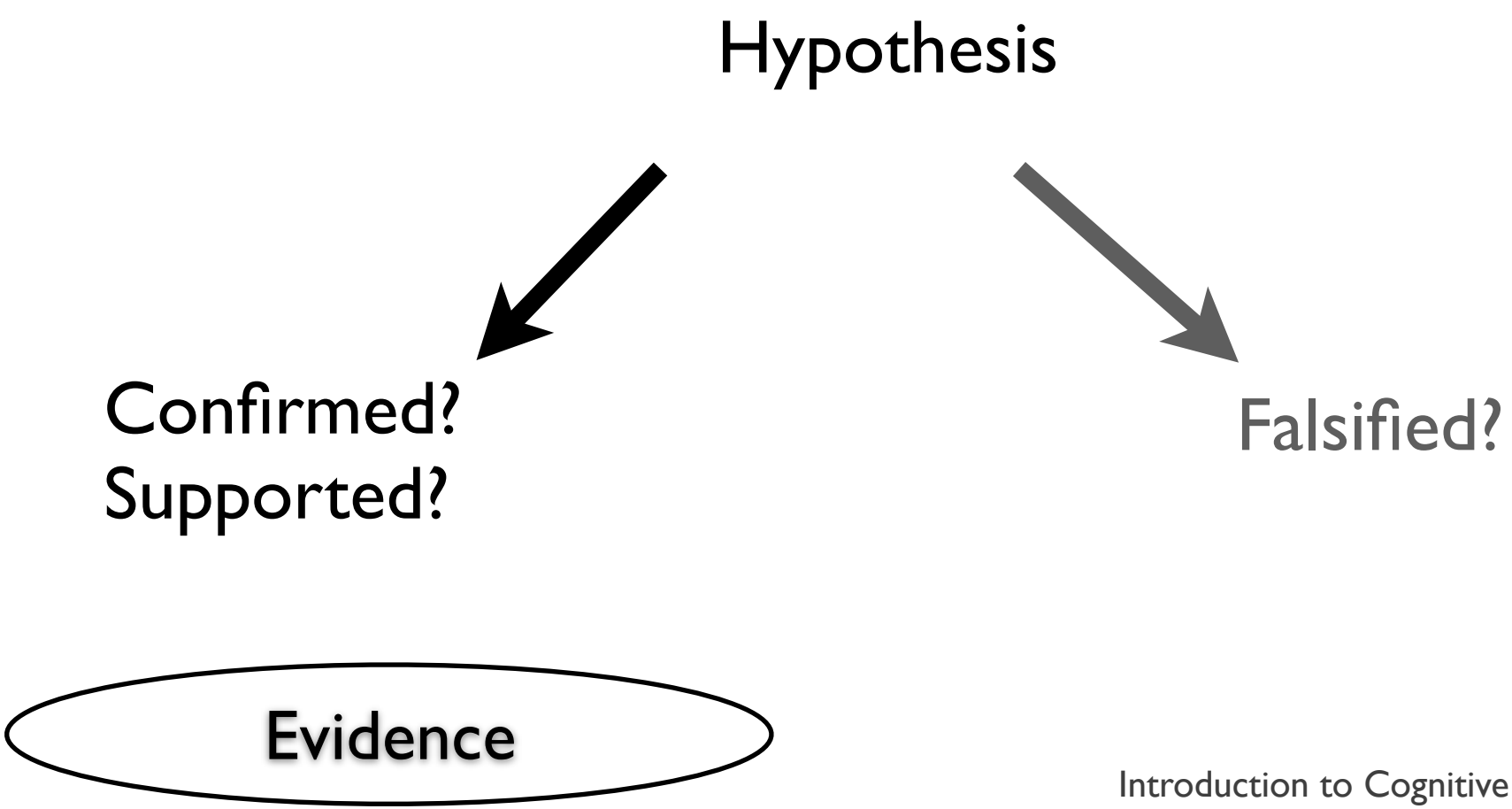
If I turn on the light switch,
the light will come on.

If I turn on the light switch,
the light will come on.

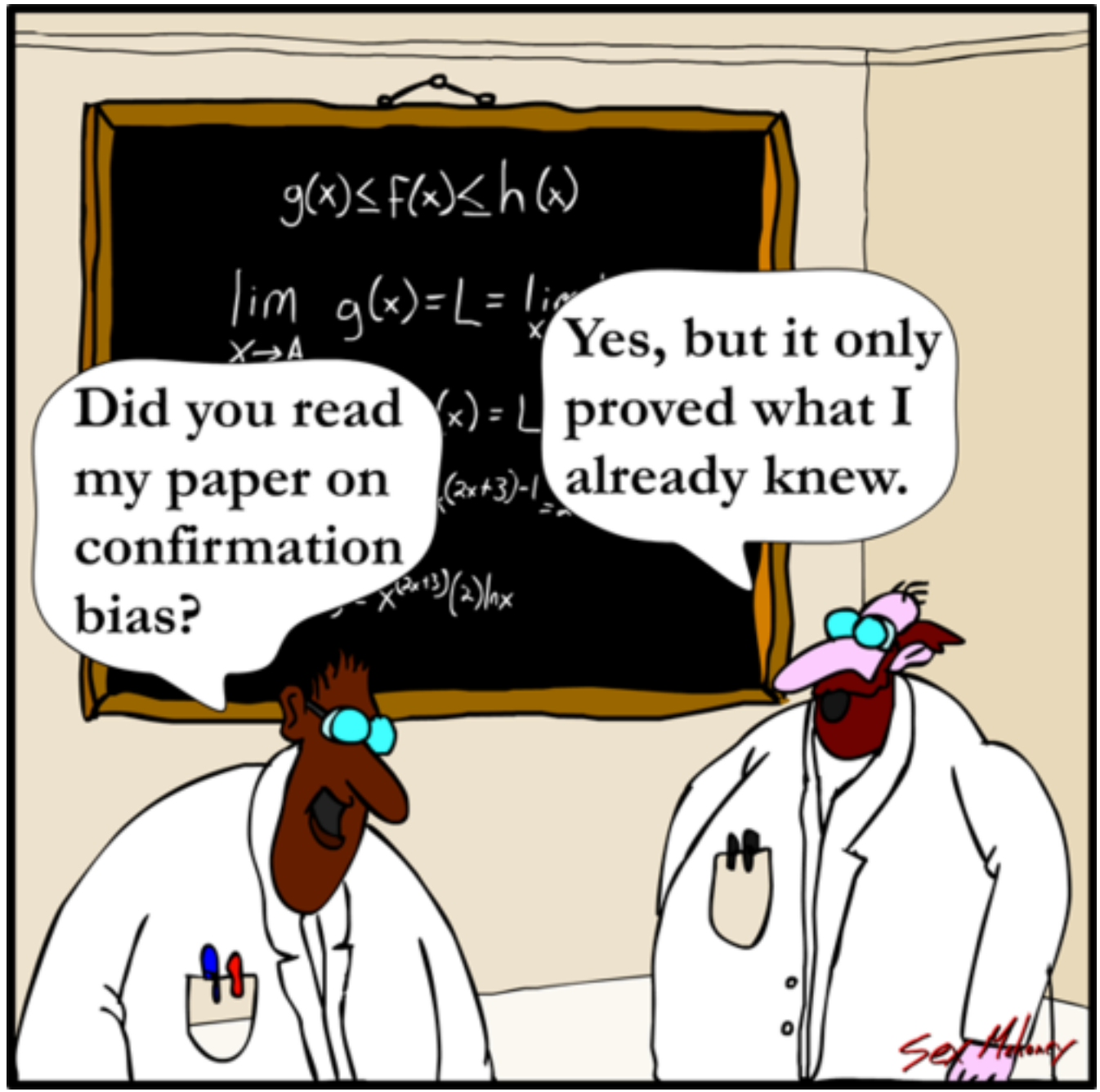


# Confirmation Bias

Many of us, a lot of the time, will tend to look for evidence that supports our hypothesis (only).

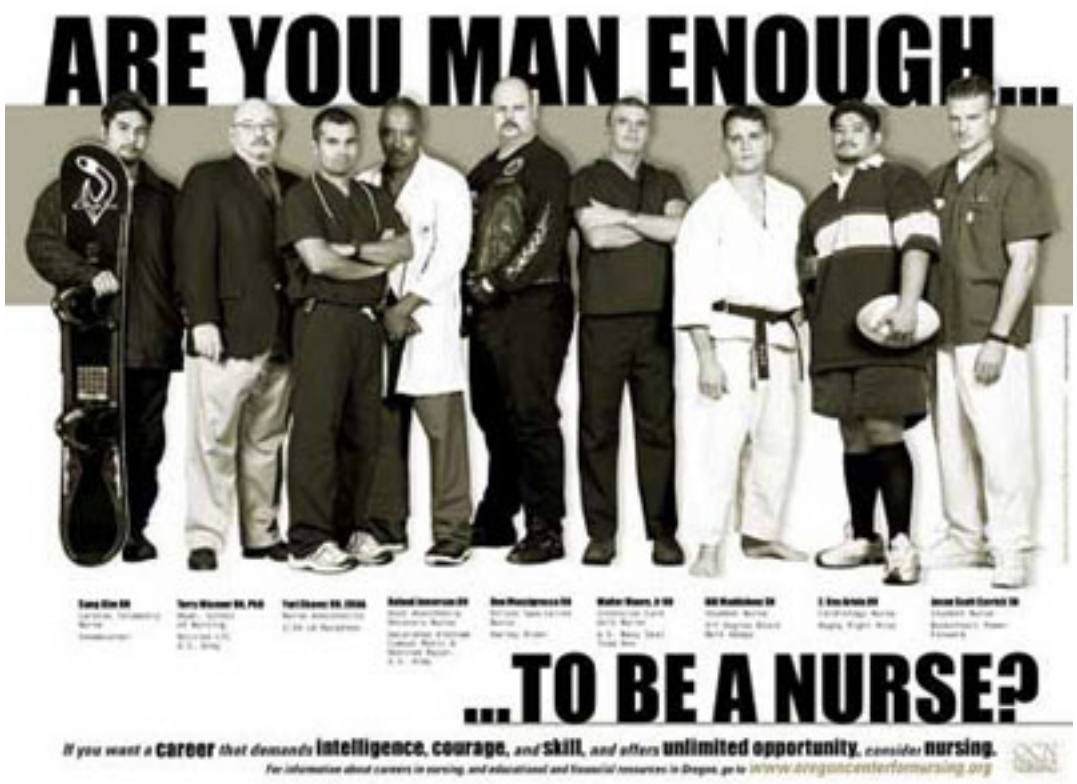


# This is a widespread tendency and a problem


$g(x) \leq f(x) \leq h(x)$
$\lim_{x \to A} g(x) = L =$
Did you read my paper on confirmation bias?
Yes, but it only proved what I already knew.

# Confirmation Bias

Easily leads to *stereotyping*



Recall Skinner's superstitious pigeons.

Could this be interpreted as a form of 'Confirmation Bias'?

Consider arguments for and against this notion.

# The Wason 2-4-6 task


These numbers conform to a general rule. Figure out what it is.

Generate other number triples you think conform to the rule, and I will confirm or disconfirm.

Did you look for confirmation of your hypothesis, or did you look to falsify it?

Hypothesis: successive even numbers

Confirming evidence: 4 6 8

Falsifying evidence: 4 6 9

# Here's a summary of the task

## The 2-4-6 Task

- Wason (1960) devised a simple experimental paradigm with which to test people's strategies in hypothesis testing.
- In the task, participants were told that the three numbers "2-4-6" confirm to a general rule that holds for a subset of all such number triples.
- The participants' task was to figure out what the general rule was.
- They did this by guessing other number triples (e.g. 4-6-8; 10-10-10, 6-4-2) and asking the experimenter whether or not that number triple also confirmed to the rule.
- They also had to provide a reason for their guess (e.g. "I think the rule might be numbers ascending in twos")
- After each guess, the experimenter told the participant whether or not the guess conformed to the rule.
- The rule was simply "three numbers in ascending order"

# Here's one *possible* interpretation of the results

- Wason found that most participants took a long time to find the correct rule. 28% of participants could not determine the rule at all.
- Participants tended to generate hypotheses that were more restrictive than the actual rule (e.g. even numbers ascending in twos)
- Participants tended to put number triples to the experimenter that conformed to their hypothesis (e.g. 4-6-8, 6-8-10,10-12-14). These triples also conformed to the actual rule.
- The participants therefore gathered evidence that supported their hypothesis about the rule (i.e. they showed **confirmation bias**).
- The only way for such participants to determine that the actual rule was more general that their hypothesis was to generate number triples that we **false** for their rule (e.g. 1-3-5, 1-2-3, etc).
- According to Wason, therefore, participants difficulty with the 2-4-6 task stemmed from their confirmation bias and their failure to falsify.

Note: it has been heavily debated whether this really stems from ‘confirmation bias’ or from peculiarities of this specific task (maximally general rule)

Use your critical faculty here.

Are you happy that the strategy shown by most people here is faulty, deficient, and somehow irrational?

# Deductive reasoning

# Deductive reasoning

- There is a much greater amount of research conducted on deductive reasoning than on inductive reasoning.
    - This is primarily for reasons of practicality. It takes many trials in order to make a single induction. Also, inductive reasoning is not precise or definite like deductive reasoning is.
    - (e.g. even in the 2-4-6 task you can never be sure you know the rule precisely).

# Deductive reasoning

- Conditional reasoning is reasoning about *propositions* using the logical relation known as *implication*.

- Formally, it is based on propositional logic
  - '*if….then*', '*if…& only if*' (also *not*, *and*, and *or* are used in propositional logic)

A proposition ***P*** is either *True* or *False*

Given several propositions, we *may* be able to validly infer other propositions.

# Modus Ponens

Given these two propositions:

*if p then q*

*p*

We can validly conclude

*q*

if ***p*** then ***q***
***p***

therefore ***q***

if ***Socrates is a man*** then ***he is mortal***
***Socrates is a man***

therefore, ***Socrates is mortal***

# Modus Tollens

Given these two propositions:

*if p then q*

*not q*

We can validly conclude

*not p*

if ***p*** then ***q***
not ***q***

therefore not ***p***

if ***there is fire*** then ***there is oxygen***
***there is*** not ***oxygen***

therefore, ***there is not fire***

## Modus Ponens

Premise 1: If *p* then *q*
Premise 2: *p*
Therefore: *q*

## Modus Tollens

Premise 1: If *p* then *q*
Premise 2: not *q*
Therefore: not *p*

Both are valid!

People tend to be better at using MP than MT

So are people good at reasoning?

## Is this valid?

If Susan is angry, then I am upset
I am upset

Therefore, Susan is angry

# Logical Fallacy

# Invalid Inference

# Fallacy 1: Affirmation of the Consequent

If *p* then *q*
*q*

FALLACY!

therefore: *p*

If I do well on the test, I will get drunk at the weekend
I got drunk at the weekend
Therefore: I must have done well on the test (I can't remember)

# Fallacy 1: Affirmation of the Consequent

If I do well on the test, I will get drunk at the weekend
I got drunk at the weekend

Therefore: I must have done well on the test (I can't remember)

Note that I may or may not have done well on the test. The argument is flawed. That's all.

# Fallacy 2: Denying the Antecedent

If *p* then *q*
not *p*

Therefore not *q*

FALLACY!

If I do well in the test, I will get drunk
I failed the test

Therefore: I will not get drunk


Affirming the antecedent (correct): A, therefore B

Denying the consequent (correct): not B, therefore not A

Affirming the consequent (wrong): B, therefore A

Denying the antecedent (wrong): not A, therefore not B

Even if A and B are both true, the first two ways of reasoning are correct, and the second two are incorrect.

So are people good at reasoning?

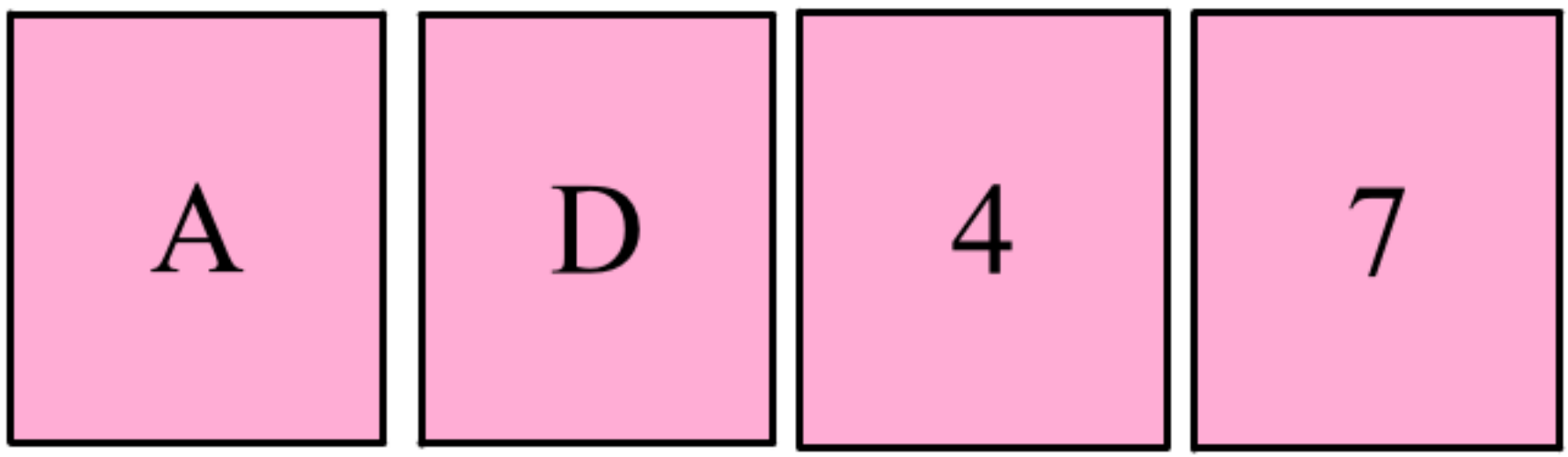
- Marcus and Rips (1979): participants were presented with examples of arguments involving modus ponens, modus tollens, affirmation of the consequent and denial of the antecedent.
- Participants were asked to judge each argument as either valid or invalid.
- Participants often incorrectly judged modus tollens invalid and incorrectly judged the two logical fallacies valid.

# The Wason Selection Task

Assume: Each card has a letter on one side and a number on the other

Rule: *If* there is a vowel on one side, *then* there is an odd number on the other.

Q: Which card(s) must you turn over to test the rule?



# If VOWEL then ODD

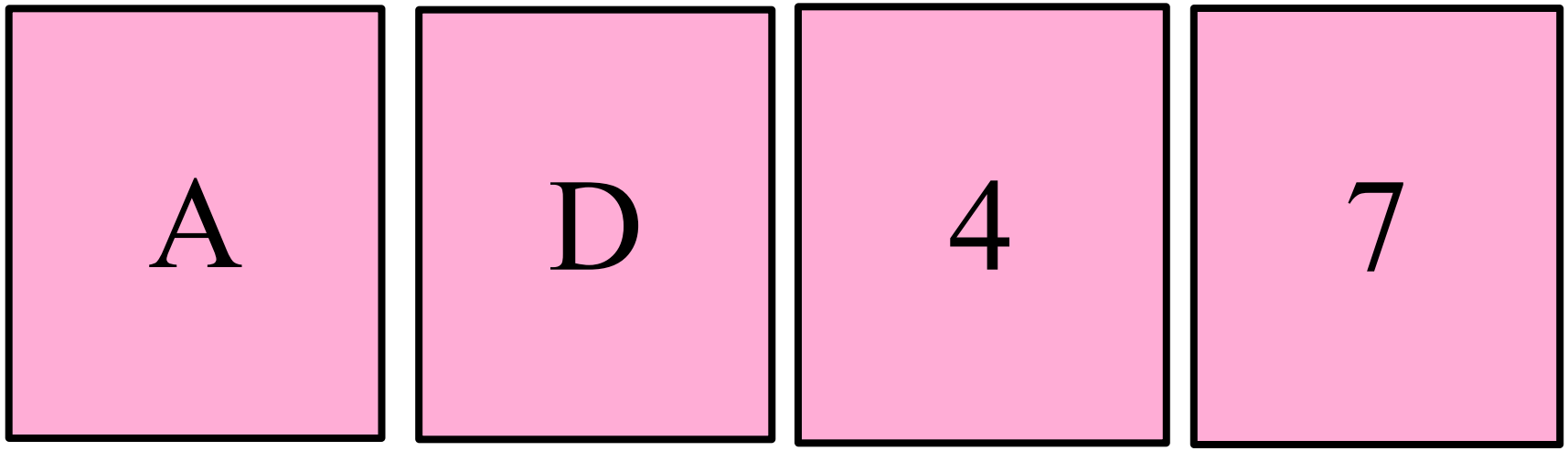
Affirming the antecedent (correct): A, therefore B

Denying the consequent (correct): not B, therefore not A

Affirming the consequent (wrong): B, therefore A

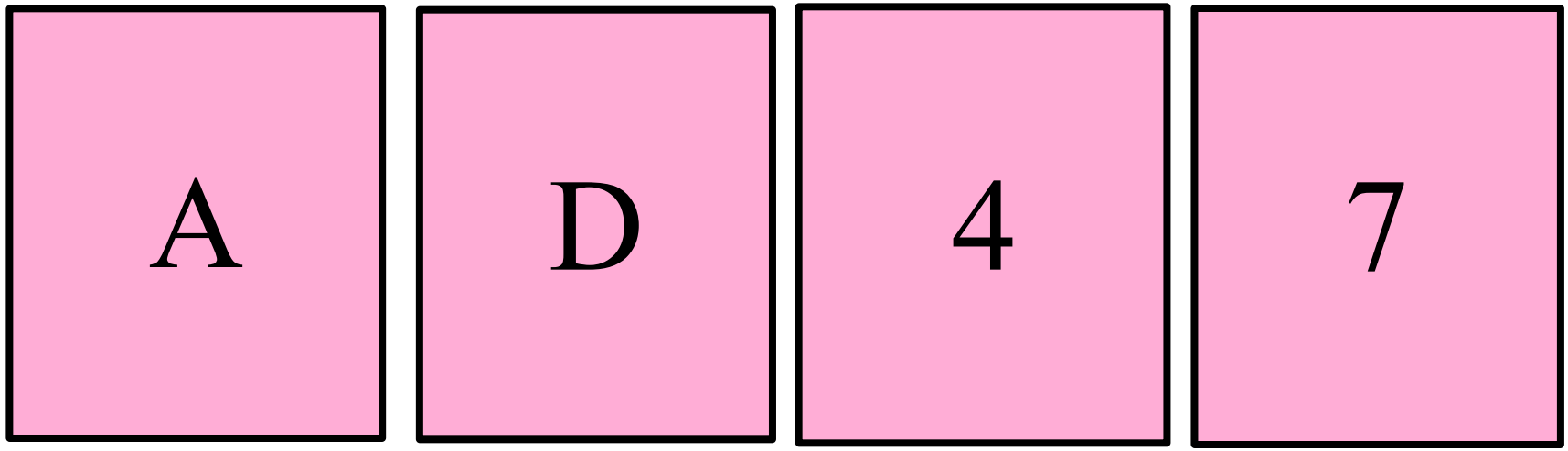
Denying the antecedent (wrong): not A, therefore not B

Note: Approx 5 - 10% of University students answer correctly on the first try.



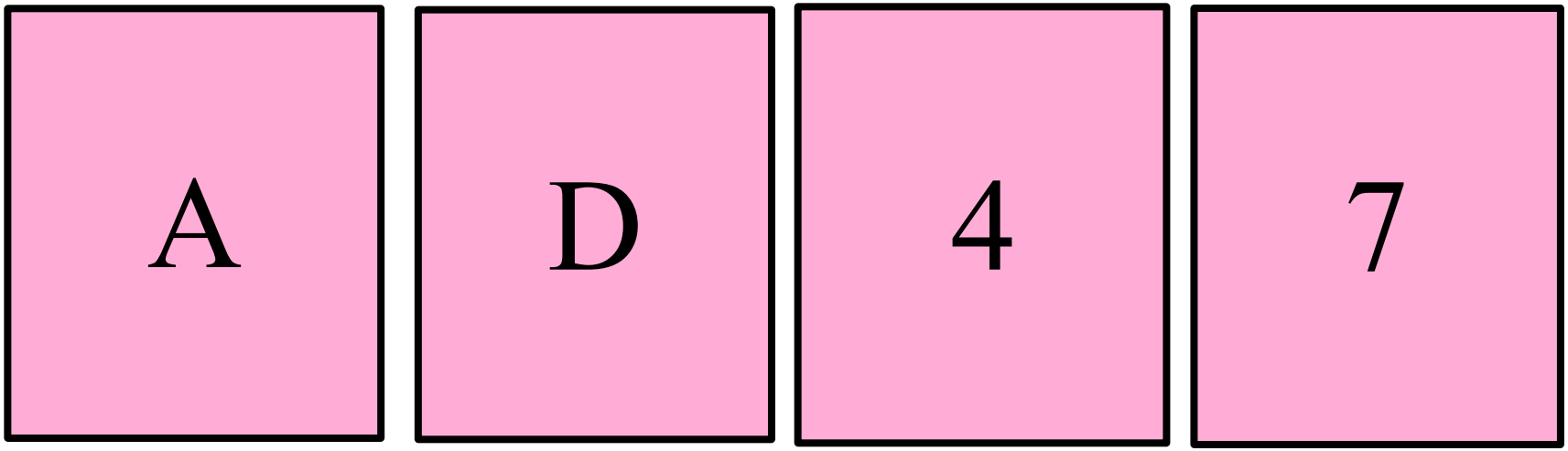

- Selecting the card with the letter A resembles use of the *modus ponens* argument: we need to check that a vowel always leads to an odd number to verify the rule.

if ***p*** then ***q***
***p***
therefore ***q***




The selection of the 4 resembles the use of the *modus tollens* argument: we need to check that not odd really does imply not a vowel to verify the rule.

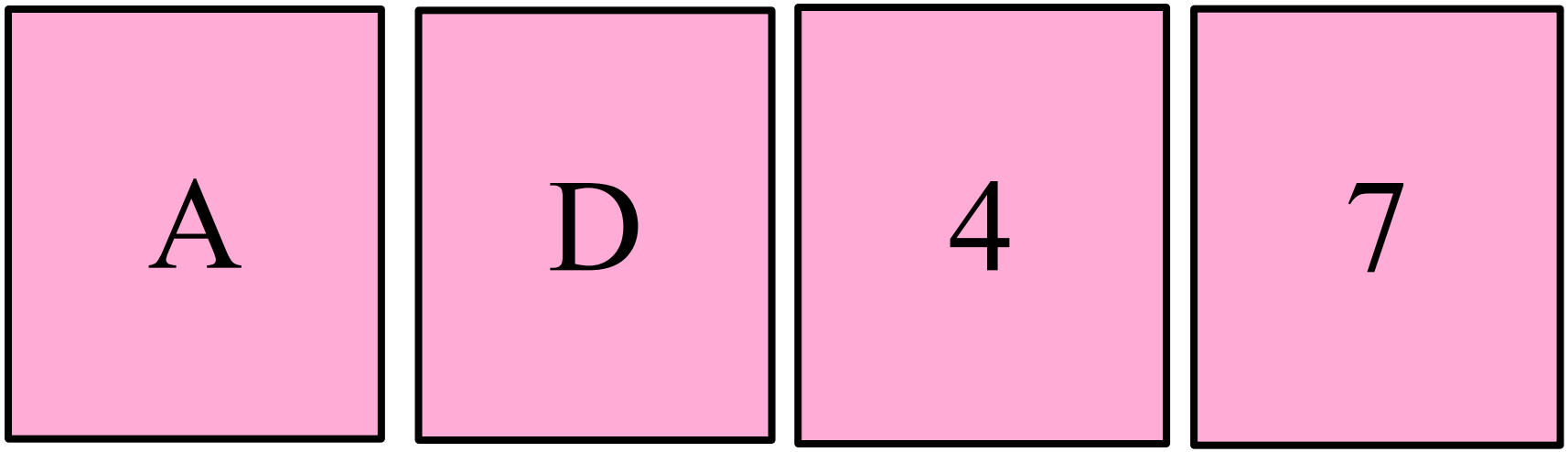
if ***p*** then ***q***
not ***q***
therefore not ***p***




Incorrectly selecting the 7 resembles the affirmation of the consequent fallacy.

If $p$ then $q$
$q$

therefore: $p$

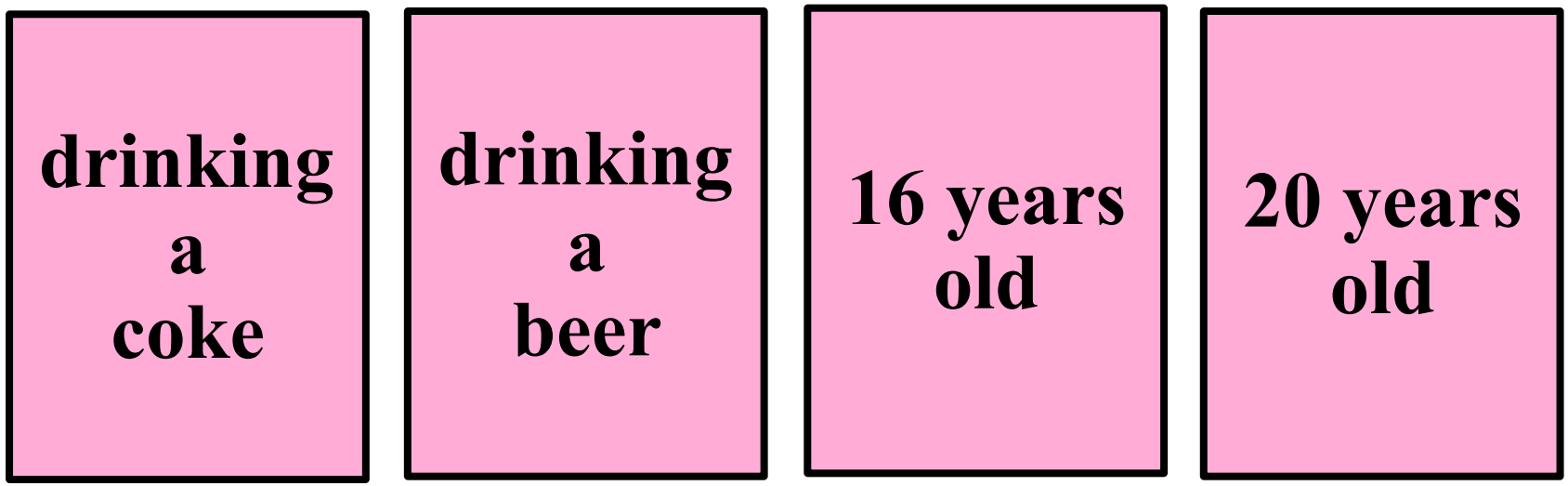



Incorrectly selecting D is…..

…. Denial of the antecedent.
Why? Why is this a fallacy?

This is left as an exercise to you

People perform much better if the propositions and rules are meaningful




- Each card has the age of a person and what they are drinking on each side. Which card/s should you turn over to find out if someone is drinking illegally?
- 60-70% of people make the correct selections on these kinds of tasks (compared to 5-10% for the original task). However, the above problem is logically identical to the original Wason selection task.
- Our ability to reason about conditional statements therefore shows some interesting context effects. **Meaning Matters!**

## Syllogistic reasoning

- A syllogism is a piece of deductive reasoning that consists of a major premise, a minor premise and a conclusion. Syllogisms have the following general from:

  | | |
  |---|---|
  | Major premise: | All/Some/No M are [not] P. |
  | Minor premise: | All/Some/No S are [not] M. |
  | Conclusion: | Therefore, All/Some/No S are [not] P. |

- Example:

  All Frenchmen are cheese-eaters
  All cheese-eaters are surrender-monkeys
  Therefore, all Frenchmen are surrender-monkeys

- The above syllogism is logically valid (even if the conclusion is untrue). The truth of a conclusion depends both on the validity of the argument and the truth of the premises.

- There are 512 ways of combining the *All*, *Some*, *No* and *Not* quantifiers, producing 512 possible syllogisms. Most of these do not produce logical arguments.
- As we saw for conditional reasoning, people often make errors when making judgments about arguments involving syllogistic reasoning.
- For example, consider:

  All French-men are cheese-eaters
  Some cheese-eaters are farmers
  Therefore, some Frenchmen are farmers

- The conclusion does not follow logically from the premises. However, people often judge the argument to be a valid one. (Johnson-Laird, 1990)
- Such findings can be explained by **belief biases** – people make judgements based on prior beliefs and knowledge rather than on the rules of logic

Andrew Marvell: To His Coy Mistress

Great poem..

Which logical fallacy does it commit?

Does that detract from the argument?

Had we but world enough, and time,
This coyness, Lady, were no crime.....

.....

But at my back I always hear
Time's wingèd chariot hurrying near;
And yonder all before us lie
Deserts of vast eternity....

....

Now therefore, while the youthful hue
Sits on thy skin like morning dew,
And while thy willing soul transpires
At every pore with instant fires,
Now let us sport us while we may,