

# Deductive Reasoning & Decision Making

Chapter 12

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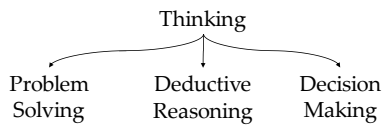
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## Complex Cognitive Tasks

Deductive reasoning and decision making are complex cognitive tasks that are part of the thinking process.



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## Deductive Reasoning

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## Deductive Reasoning

Is a process of thinking in a logical way, where conclusion are drawn from the information given, for example:

if there are clouds in the sky then it will rain.

Information

Conclusion

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## Deductive Reasoning

There are two kinds of deductive reasoning:

1. Conditional Reasoning
2. Syllogisms

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## Conditional Reasoning

Conditional reasoning (or propositional reasoning), tells us about the relationship between conditions.

Conditional reasoning consists of **true** if-then statements, used to deduce a **true** conclusion. Though the premises may be true the conclusions can be **valid** or **invalid**.

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## Valid Conclusion

**Premises** If a student is in cognitive psychology,  
Then she must have completed her  
general psychology requirements.

**Observation** Jenna is in cognitive psychology class

**Conclusion** So Jenna must have completed her  
general psychology requirements.

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## Valid Conclusion

**Premises** If a student is in cognitive psychology,  
Then she must have completed her  
general psychology requirements.

**Observation** David has NOT completed his general  
psychology requirements.

**Conclusion** So David must NOT be in cognitive  
psychology class.

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## Valid Conclusions

Affirming the antecedent	If p is true then q is true p is true q is true	Modus ponens	Valid
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If Newton was a scientist, then he was a person  
Newton was a scientist  
Newton was a person

Denying the consequent	If p is true then q is true q is not true p must be not true	Modus tollens	Valid
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If an officer is a general, then he was a captain.  
Gerald is NOT a captain,  
So he NOT a general.

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## Invalid Conclusions

Affirming the consequent	If p is true then q is true q is true p is true	Invalid
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If this is a carrot, then it is a vegetable  
This is a vegetable  
So this is a carrot

Denying the antecedent	If p is true then q is true p is not true q must be not true	Invalid
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If Reagan is a rocket scientist, then he is human  
Reagan is NOT a rocket scientist,  
So he is NOT a human

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## Invalid Conclusions

Portion of the Statement			
	Antecedent      Consequent		
Affirm	<table border="1"> <tr> <td> <i>It is an apple</i>  <i>Then it is fruit</i>                      Affirming the Antecedent                      (valid)                 </td><td> <i>It is a fruit</i>  <i>Then it is apple</i>                      Affirming the consequent                      (invalid)                 </td></tr> </table>	<i>It is an apple</i> <i>Then it is fruit</i> Affirming the Antecedent (valid)	<i>It is a fruit</i> <i>Then it is apple</i> Affirming the consequent (invalid)
<i>It is an apple</i> <i>Then it is fruit</i> Affirming the Antecedent (valid)	<i>It is a fruit</i> <i>Then it is apple</i> Affirming the consequent (invalid)		
Deny	<table border="1"> <tr> <td> <i>It is NOT an apple</i>  <i>Then it is NOT a fruit</i>                      Denying the antecedent                      (invalid)                 </td><td> <i>It is NOT a fruit</i>  <i>Then it is NOT apple</i>                      Denying the consequent                      (valid)                 </td></tr> </table>	<i>It is NOT an apple</i> <i>Then it is NOT a fruit</i> Denying the antecedent (invalid)	<i>It is NOT a fruit</i> <i>Then it is NOT apple</i> Denying the consequent (valid)
<i>It is NOT an apple</i> <i>Then it is NOT a fruit</i> Denying the antecedent (invalid)	<i>It is NOT a fruit</i> <i>Then it is NOT apple</i> Denying the consequent (valid)		

If this is an apple, Then it is fruit

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## Daily Life

Some valid examples of propositional logic in our daily life.

1. Parking permitted between 6:00-7:00 PM. If the time is between 6:00-7:00 PM then parking is permitted. It is 6:30 ...therefore parking is permitted (affirming the antecedent, valid)
2. If Tom is found guilty, he is going to jail. Tom did not go to jail therefore he was not guilty (denying the consequent, valid)

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## Syllogisms

Another form of deductive reasoning is called syllogism. **Syllogisms** consists of two statements (premises that are assumed true) that lead to a conclusion. Syllogism refer to quantities, such as **all, some, none** etc. Conclusion can be **valid, invalid** or **indeterminate** based on observation or data.

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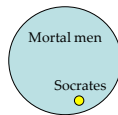
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## Valid Syllogistic Forms

Major premise: All men are mortal.  
Minor premise: Socrates is a man.  
Conclusion: Therefore, Socrates is mortal.



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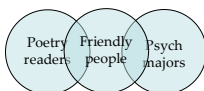
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## Invalid Syllogistic Forms

Major premise: Some psychology majors are friendly  
Minor premise: Some friendly people read poetry  
Conclusion: Therefore some psychology majors read poetry



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## Indeterminate Forms

Major premise: All men are mortal.  
Minor premise: Socrates is a man.  
Conclusion: Therefore, Socrates is mortal.



Indeterminate

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## Errors in Reasoning

Generally there are two kinds of errors in deductive reasoning. One based on our beliefs and the other on failing to test the prediction

1. **Belief-based error:** I saw clouds in the sky yesterday and it did not rain, so it will not rain today.

2. **Hypothesis-testing error:** Generalize on the type of clouds, thus any kind of cloud could bring rain.

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## Belief-Bias Effect

The tendency for one's preexisting beliefs (everyday experiences) leads us to distort our logical reasoning leading invalid conclusions.

This is a top-down process.

If my finger is cut, **then** it bleeds. My finger is bleeding. Therefore my finger is cut.

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## Individual Differences

People are more inclined to have belief-biases if they score low on flexible thinking.

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## Cognitive Functions

Research has shown that conditional reasoning and syllogisms tasks both affect the **same** cognitive functions (Gilhooly, 1996; Klauer et al., 2000; Matlin 1994; Stanovich, 1999). **How?**

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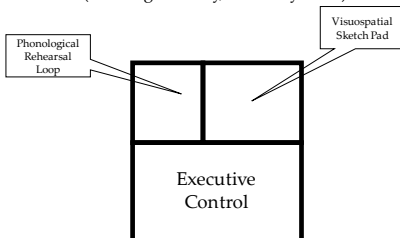
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## Executive Control

(Working memory, Baddeley 1986)



Propositional reasoning relies on executive control.

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## Negative Information

Load on central executive increases if negative information is used in propositional reasoning.

1. If today is NOT Friday, **then** we will have NO Quiz today.
2. If today is Friday, **then** we will have Quiz today.

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## Abstract vs. Concrete

Handling abstract information in propositional reasoning is harder than concrete information.

If an object is red, **then** it is a rectangle. The object is NOT rectangle. Therefore it is not red. (denying the consequent, valid).

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## Confirmation Bias

The approach in people tend to confirm a hypothesis than disconfirm it.



If a card has a vowel on one side then it has an even number on the other side. Which card would you pick?

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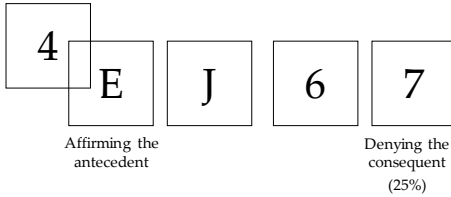
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## Confirmation Bias

Majority (89%) of people picked the “E” card (Oaksford & Chater, 1994).



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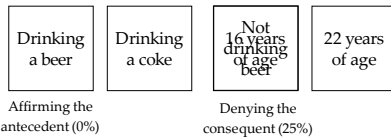
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## Concrete Information

Conformational bias may be removed if the propositional logic presents real-life situations.



If a person is drinking beer then the person must be over 19 years of age. Which card would you pick?

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## Transfer of Tasks

People tend to make conditional reasoning errors because they are mentally fixed on a task they have performed earlier. The earlier task may be similar to the new task at hand.

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## Decision Making

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## Decision Making

For conditional reasoning and syllogisms we have prescribed rules. Using these rules lead to form valid conclusions. However, in decision making there are no predetermined rules to follow. Thus the task becomes difficult.

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## Decision Making



Herbert Simon

Theory of bounded rationality  
(Simon, 1957).

States that people use simple strategies in decision making usually making "irrational decisions".

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## Bounded Rationality



I like the sporty look of the car.



I like that diamond, because my neighbor has one too!

Decisions thus are based on personal biases.

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## Information

The information required to make a decision is not trustworthy. The information may be incomplete.

“The best decision is a well informed decision.”

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## Decision-Making Heuristics

Heuristics are general strategies that typically produce a correct solution. Heuristics are efficient but do not guarantee correct solutions.

Heuristics are generally well adapted strategies that are used by human beings.

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## Chance or Fate?

Three American presidents (Adams, Jefferson, and Monroe) died on 4<sup>th</sup> of July (in different years). Is this fate or chance?

Nonrandom events make us think of them as mystical or metaphysical.

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## Representative Heuristic

Throw 6 coins

Likely Outcome?

H T H H T H	High
T T T H H H	Low

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## Representative Heuristic

Throw 6 coins

Mathematical  
Outcome

H T H H T H	(1/64)
T T T H H H	(1/64)

$(\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2}) = 1/64$   
Mathematical probability is the same.

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## Sample Size

Large Hospital

Small Hospital

45 babies born each day

15 babies born each day

50% of these babies are boys each day

Recorded for 1 year, and counted days when 60% or more boys were born.

Which hospital recorded more days when 60% boys were born?

☐ Large Hospital

☒ Small Hospital

☐ About the same (say, within 5% of each other)

(Kaheman and Tversky, 1972)

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## Sample Size

Population  
parameter = 50% boys

45

15

### Law of large numbers

Larger sample ( $>N$ ) more representative of the population and present fewer deviations.

Decisions made on larger sample are more accurate than smaller sample ( $<N$ ). If decisions are made on small sample we run into what is called small-sample fallacy.

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## Base Rates

If you were to meet a man, slim, short, wears glasses and likes poetry. What do you think would his profession would be?

Ivy league professor or truck driver?

Probability that this person is a truck driver is far greater than an ivy league professor just because there are more truck drivers than ivy league professors.

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## Base Rates

Steve is very shy and withdrawn, invariably helpful, with little interest in people, or in the world of reality. A meek and tidy soul, he has need for order and structure and a passion for detail.

What is Steve's profession?

Salesperson   Farmer   Pilot   Librarian   Physician  
Highest Base Rate

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## Bayes' Theorem

The theorem states that judgments should be influenced by two factors: 1) Base rate and 2) Likelihood ratio.

Likelihood ratio assess whether description is more likely to apply to one population than the other.

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## Conjunction Fallacy

Linda is 31 years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice and also participated in antinuclear demonstrations. Rank 1 most likely 8 least likely.

- ☐ Linda is a teacher at an elementary school.
- ☐ Linda works in a bookstore and takes Yoga classes.
- ☐ Linda is active in feminist movement.
- ☐ Linda is a psychiatric social worker.
- ☐ Linda is a member of the League of Women Voters.
- ☐ Linda is a bank teller.
- ☐ Linda is an insurance salesperson.
- ☐ Linda is a bank teller and is an active in feminist movement.

(Kaheman and Tversky, 1983)

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## Conjunction Rule

Conjunction rule states that the probability of a conjunction to two events cannot be larger than the probability of either of its constituent events.



(Kaheman and Tversky, 1983)

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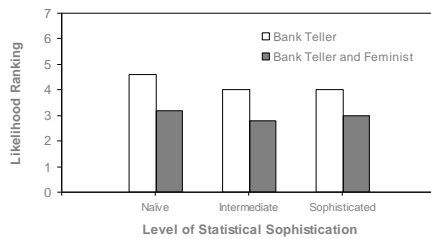
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## Students of Statistics



Tversky and Kahneman (1983) discovered that people tend to judge the probability of conjunction greater than constituent events.

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## Availability Heuristic

Estimating the likelihood of events based on their availability.

If instances come readily to mind (without effort), we presume such events are common. Thus use this heuristic to make judgments or decisions.

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## Availability Heuristic

Washing your car causes it to rain. You are much more likely to remember the times that you washed your car and it rained because of the ensuing anger or disappointment, than all the times you washed your car and it didn't rain.

<http://webiocosm.blogspot.com>

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## Recency & Availability

Memory declines with time. So most recent items are recalled more accurately, therefore most recent memories serve as heuristics.

Terrorism is quickly associated with 9/11 because it is fresh in our memories. Less so with Okalahoma terrorist bombing.

<http://webiocosm.blogspot.com>

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## Familiarity & Availability

Factor of familiarity also distorts our estimation of how frequently events take place. People who know many divorced individuals are likely to over estimate the national divorce rates than people who don't (Kozielecki, 1981).

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## Familiarity

Louisa May Alcott	George Nathan	Toni Morrison
Harriet Beecher Stowe	Thomas McGuane	Hubert Selby, Jr.
Maya Angelou	Allan Nevins	Sue Grafton
John Dickson Carr	Laura Ingalls Wilder	Agatha Christie
Virginia Woolf	Frederick Rolfe	Richard Watson Gilder
Robert Lovett	Edward George Lytton	Henry Crabb Robinson
Jane Austen	Brain Hooker	James Hunt
Emily Bronte	Arthur Hutchinson	Joseph Lincoln
Alice Walker	Danielle Steel	Joyce Carol Oates
Judy Blume	Michael Drayton	

14 Women's names and 15 men's names.

(Kaheman and Tversky, 1973)

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## Illusory Correlation

Illusory correlation occurs when people believe that there is a statistical correlation between variables, when in fact there is none.

Redelmeier and Tversky (1996) assessed 18 arthritis patients over 15 months, whilst also taking comprehensive meteorological data. Virtually all of the patients were certain that their condition was correlated with the weather. In fact the actual correlation was close to zero.

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## Simulation Heuristic

Where availability heuristic refers to the ease with which we recall *examples*, Simulation heuristic refers to the ease with which we can think of a particular *scenario*, or series of events.

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## Simulation Heuristic Applications

Simulation heuristic have been used to affect consumer behavior.

Gregory et al (1982) observed people were less likely to subscribe to cable TV if door-to-door canvassing was carried out compared to if they made scenarios on how much convenient and inexpensive the service would be.

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## Anchoring and Adjustment Heuristic

The heuristic begins with a first approximation (anchor) followed by adjustments around this approximation.

How many delegates in the UN are from Africa?

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## Anchoring and Adjustment Heuristic

Spun a wheel (0-100). Took the random number and asked subjects to estimate delegates above and this number. When the number was small (10) estimations were larger (25%) and when the number was large (65) the estimations were smaller (45%).

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## Anchoring and Adjustment Heuristic

Judge answer within 5 seconds:

- $8 \times 7 \times 6 \times 5 \times 4 \times 3 \times 2 \times 1$  (2250)
- $1 \times 2 \times 3 \times 4 \times 5 \times 6 \times 7 \times 8$  (512)

40,320

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## Anchoring and Adjustment Heuristic Applications

Stereotype about a group (females). One uses this stereotype as an anchor when judging an individual (a particular female) and makes adjustments in the stereotype after looking at individual characteristics of this particular individual.

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## Anchoring and Adjustment Heuristic Applications

Real-estate agents were asked to make an offer on a house priced \$66,000 or \$84,000 separately. Their offer was \$65,000 when the house was less expansively priced and \$73,000, when the house was priced more.

Larger adjustments when price of the house is more and fewer adjustments when the house was priced low. But other factors may affect our judgments.

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## Framing

Decisions can be affected by how an issue is posed. Framing can significantly affect decisions and judgments.

What is the best way to market ground beef?  
(Johnson, 1987)

1. This ground beef has 20% fat
2. This ground beef is 80% lean?

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## Framing

Decisions based on framing effect are influenced by two factors

1. The background context of choice
2. The way in which the question is framed

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## Background Information

**Problem 1:** Imagine you decided to see a play and you paid \$20.00 for its ticket. Unfortunately in the midst of things you lost the ticket. Would you buy another ticket for \$20.00? **46%**

**Problem 2:** Imagine you decided to see a play. The cost of the ticket is \$20.00. As you are about to pay for the ticket you realize that you have lost one of your \$20.00 bill. Would you buy the ticket? **88%**

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## Wording the Question

If program A is adopted 200 people will be saved.  
If program B is adopted there is one-third probability that 600 will be saved and two-third probability that no one will be saved.

A: 72%, B: 28%

If program C is adopted 400 people will die.  
If program D is adopted, there is one-third probability that no body will die, and there is two-third probability that 600 will die

C: 22%, D: 78%

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## Overconfidence

A tendency to be more confident than correct. A tendency to overestimate the accuracy of one's beliefs and judgments.

At a stock market both the seller and buyer may be confident about their decisions on a stock



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