

Cognition and language

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1. Concepts, thinking, reasoning and language
2. Problem solving, decision making and creativity

1 Concepts, thinking, reasoning and language

Thinking is the mental handling of information (images, concepts and words) to understand, reason, solve problems and decide; concepts are its building blocks, reasoning draws conclusions from them, and language, a rule-governed system of symbols, both carries and shapes thought.

Core facts

- **Cognition:** all the mental processes of knowing: perceiving, remembering, thinking, reasoning, problem solving, using language.
- **Thinking:** a **higher mental process**; it works on **representations** (images, concepts, words), is **goal-directed**, **relies on knowledge already possessed** and is **inferred from overt behaviour** (we cannot see it directly).
- **Building blocks of thought: mental images** (picture-like representations of sensory experience), **concepts** (mental categories), and **language / symbols** (propositions: statements linking concepts).
- **Concept:** a mental category that groups objects, events, ideas or people sharing common features (e.g. "fruit", "democracy"). Concepts are the **units of knowledge**; once formed they are **organised into categories and hierarchies** and stored in **long-term (semantic) memory**.
- **Concrete concepts** are often coded as images; **abstract concepts** (justice, honesty) take a **verbal, descriptive code**.
- **Kinds of concepts: artificial / formal** (clearly defined by rules: a square, a triangle) vs **natural** (formed from everyday experience, with **fuzzy boundaries**: bird, game, furniture).
- **By rule** (Bruner, Goodnow and Austin, *A Study of Thinking*, 1956): **conjunctive** (must have all listed features: "a red square"), **disjunctive** (one feature **or** another: a "strike" in baseball is a missed swing **or** an unswung pitch in the zone **or** a foul hit before two strikes), **relational** (defined by a relation: "taller than", "brother").
- **Prototype:** the **best, most typical example** of a concept (robin or sparrow for "bird", not penguin). **Prototype theory:** Eleanor Rosch (1970s). **Exemplar theory:** we compare a new item with remembered examples.
- **Levels of concepts (Rosch): superordinate** (animal) → **basic level** (dog: learnt first and used most) → **subordinate** (Labrador).
- **First experimental study of concept formation: Clark Hull, 1920** (Chinese characters sharing a common element).
- **Bruner's strategies of concept attainment: focusing** (conservative focusing, focus gambling) and **scanning** (simultaneous, successive).
- **Reasoning:** drawing conclusions from facts or premises.
 - **Deductive:** general → particular; conclusion follows **with certainty** if the premises are true and the form is valid. Classic form: the **syllogism** (two premises + conclusion; Aristotle).
 - **Inductive:** particular → general; conclusion is only **probable** (the method of science).
 - **Analogical:** reasoning from a similarity between relations ("hand is to glove as foot is to sock").

- **Piaget** (Swiss): children build an **internal representation of the world** through their own thinking. Units: **schema**; processes: **assimilation, accommodation, equilibration**.
- **Piaget's four stages: sensorimotor** (0-2 years; object permanence), **pre-operational** (2-7; symbols, egocentrism, no conservation), **concrete operational** (7-11; conservation, reversibility, classification, seriation), **formal operational** (11+; abstract, hypothetico-deductive thinking).
- **Bruner's modes of representation: enactive** (action) → **iconic** (images) → **symbolic** (language).
- **Vygotsky** (Russian; *Thought and Language*, 1934): **zone of proximal development (ZPD)**, help from a more knowledgeable other; **private speech** turns into **inner speech**. The word **scaffolding** was coined later by **Wood, Bruner and Ross (1976)**.
- **Language**: a system of **arbitrary symbols** combined by **rules** to communicate meaning. Features: **symbolic, rule-governed (structured), generative / productive** (endless new sentences from finite words), **displacement** (we can talk of the past, the future, the absent).
- **Units of language: phoneme** (smallest unit of **sound**; English has about 40-45), **morpheme** (smallest unit of **meaning**; "unhappiness" = un + happy + ness), **syntax** (rules for ordering words into sentences), **semantics** (meaning), **pragmatics** (rules for use in social context).
- **Stages of language development: crying** (birth) → **cooing** (about **2 months**, vowel-like sounds) → **babbling** (about **6 months**, consonant-vowel strings "ba-ba") → **one-word / holophrase** stage (about **12 months**; one word stands for a whole sentence) → **two-word / telegraphic speech** (about **18-24 months**; "want milk", function words left out) → rapid growth of grammar (2-5 years).
- **Overregularisation (overgeneralisation)**: "goed", "mouses": shows the child is **applying rules**, not just copying.
- **B.F. Skinner** (*Verbal Behavior*, 1957): language is learnt by **imitation, reinforcement and shaping** (a learning / behaviourist view).
- **Noam Chomsky**: children are born with a **Language Acquisition Device (LAD)** and a **universal grammar**; language is **innate**, a nativist view (*Syntactic Structures*, 1957; his critical review of Skinner, 1959). **Deep structure** (meaning) vs **surface structure** (the words said); **transformational-generative grammar**.
- **Critical period hypothesis for language: Eric Lenneberg** (1967): language is acquired most easily before **puberty**.
- **Benjamin Lee Whorf** (with Edward Sapir): **linguistic relativity hypothesis**: the language we speak shapes (strong form: **determines**) the way we think and perceive.
- **Piaget: thought comes first**; language reflects the level of thinking. **Vygotsky**: thought and language have **separate roots** and **merge around age 2**, after which language becomes a tool that shapes thought.

Explained

1. What thinking is, and what it is not. Thinking is a covert activity: a psychologist infers it from what a person says and does, from reaction times or from think-aloud reports. It is usually carried on in **images or words**, draws on what is already stored in memory, and is directed at a goal (understanding, deciding,

solving). It ranges from **autistic / associative thinking** (daydreaming, free flow of ideas) to **directed thinking** (reasoning, problem solving). Concepts used in everyday thinking are often **fuzzy**, not sharply defined, which is why we argue about whether a tomato is a "vegetable".

2. How concepts are formed. A child meets several examples, notices the **features they share** (abstraction), separates them from irrelevant features (discrimination), and extends the label to new cases (generalisation). Early errors show the process: a child may call every four-legged animal "dog" (**overextension**) or only the family's own dog "dog" (**underextension**). Hull's 1920 experiment had people learn nonsense names for Chinese characters; they came to attach a name to the shared radical without being able to say what it was, showing that concepts can be formed without conscious rules.

3. Two views of how we hold natural concepts

View	A concept is held as	Example	Strength
Defining features (classical)	a list of necessary features	triangle: 3 straight sides	fits artificial concepts
Prototype (Rosch)	a typical "best" member	sparrow for bird	explains typicality, fuzzy edges
Exemplar	many stored examples	all birds you have seen	explains variety within a category

4. Reasoning compared

Point	Deductive	Inductive
Direction	general → specific	specific → general
Conclusion	certain, if premises true and form valid	probable, can be overturned
Example	All men are mortal; Ram is a man; so Ram is mortal	Every crow I have seen is black; so all crows are black
Used in	logic, mathematics	science, everyday generalising

A deductive argument can be **valid but untrue** (valid form, false premise). Common errors: **belief bias** (accepting a conclusion because we believe it, not because it follows), **confirmation bias** (looking only for supporting evidence), **atmosphere effect** (a negative or "some" premise pulling us toward a similar conclusion).

5. Development of thinking (Piaget in brief). In the **sensorimotor** stage the infant knows the world through senses and actions; **object permanence** develops in the second half of the first year, and by about 18-24 months the child begins **mental representation** (deferred imitation, pretend play). The **pre-operational** child uses symbols and language but is **egocentric**, shows **animism** and **centration**, and fails **conservation** tasks. The **concrete operational** child conserves and classifies but needs concrete objects. The **formal operational** adolescent can reason about hypotheses and abstractions ("what if"). (Detailed development is in the development unit.)

6. How language develops. Before speech, infants **perceive** all the speech sounds of the world's languages; by about 10-12 months they lose sensitivity to sounds their own language does not use. Babbling at first contains sounds of many languages and narrows to those of the home language. Comprehension

runs ahead of production: a child understands many words before saying the first. After the **vocabulary spurt** (around 18 months) words are added very fast; telegraphic two-word sentences already follow the word order of the language. By about 5 the child has most of the basic grammar.

7. Skinner vs Chomsky

Point	Skinner (learning)	Chomsky (nativist)
Source	environment	inborn capacity (LAD)
Mechanism	imitation, reinforcement, shaping	universal grammar set by the language heard
Explains well	accent, vocabulary, local words	speed, same stages everywhere, novel sentences, "goed"
Weakness	children say what they never heard; parents correct truth more than grammar	LAD is not directly observable; little role for social input

Chomsky's **poverty of the stimulus** argument: the speech a child hears is too limited and error-filled to explain the grammar the child ends up with. **Interactionists** (Bruner's **LASS**, Language Acquisition Support System; Vygotsky) accept an inborn readiness but stress talk with caregivers ("motherese" / child-directed speech). Support for a critical period: children deprived of language until late (the case of "Genie", found in 1970) never fully mastered grammar.

8. Language and thought: three positions

Position	Thinker	Claim
Language determines / shapes thought	Whorf (Sapir-Whorf)	speakers of different languages think differently
Thought comes first	Piaget	language reflects thinking already achieved
Separate roots, then interaction	Vygotsky	language becomes a tool of thought after about age 2

Evidence: the **strong** Whorfian claim (thought impossible without the word) is not supported; Eleanor Rosch (then Heider) found that the Dani of New Guinea, with only two colour words, still remembered focal colours well. The **weak** form, that language **influences** attention, memory and categories, has support.

Common traps

✗ "Concepts used in thinking are clear and unambiguous." ✓ Natural concepts are often **fuzzy**; only artificial (formal) concepts have sharp definitions.

✗ "The concept is the basic unit of knowledge in short-term memory." ✓ Concepts are units of knowledge held in **long-term (semantic) memory**.

✗ "Thinking can be observed directly." ✓ It is **inferred** from overt behaviour.

✗ "A prototype is the first example a child learns." ✓ A prototype is the **most typical** example of a concept.

✗ "Inductive reasoning gives a certain conclusion." ✓ **Deductive** can give certainty; inductive gives only **probability**.

✗ "Phoneme = smallest unit of meaning." ✓ Phoneme = smallest unit of **sound**; **morpheme** = smallest unit of **meaning**.

✗ "Syntax deals with meaning." ✓ Syntax = **word order and sentence rules**; meaning = **semantics**; social use = **pragmatics**.

✗ "Babbling comes before cooing." ✓ **Cooing (~2 months)** → **babbling (~6 months)** → first word (~12 months).

✗ "Universal grammar / LAD: Skinner or Piaget." ✓ **Chomsky**. Skinner = reinforcement and imitation (*Verbal Behavior*, 1957).

✗ "Internal representation of the world through thinking: Vygotsky." ✓ **Piaget**; Vygotsky stressed **social interaction**, ZPD and inner speech.

✗ "Linguistic relativity: Chomsky." ✓ **Whorf** (with Sapir).

✗ "Vygotsky coined 'scaffolding'." ✓ Scaffolding was coined by **Wood, Bruner and Ross (1976)**, building on Vygotsky's ZPD.

Quick revision

- Thinking: higher mental process, goal-directed, uses images, concepts, words; inferred from behaviour.
- Concept = mental category; units of knowledge in long-term memory; abstract concepts take a verbal code.
- Natural (fuzzy) vs artificial (defined); conjunctive, disjunctive, relational (Bruner 1956); Hull 1920.
- Prototype = most typical example (Rosch); basic level learnt first.
- Deductive (general → particular, certain; syllogism) vs inductive (particular → general, probable).
- Piaget: schema, assimilation, accommodation; sensorimotor 0-2, pre-op 2-7, concrete 7-11, formal 11+.
- Vygotsky: ZPD, private → inner speech; scaffolding = Wood, Bruner, Ross 1976. Bruner: enactive, iconic, symbolic.
- Phoneme (sound), morpheme (meaning), syntax (order), semantics (meaning), pragmatics (use).
- Cooing 2 m → babbling 6 m → holophrase 12 m → telegraphic 18-24 m; "goed" = overregularisation.

- Skinner (reinforcement) vs Chomsky (LAD, universal grammar, deep/surface structure); Lenneberg critical period; Whorf linguistic relativity.

2 Problem solving, decision making and creativity

Problem solving is thinking directed at reaching a goal past an obstacle, by algorithms (sure but slow) or heuristics (fast but fallible); decision making is choosing among options, often by mental short-cuts that cause predictable biases; creativity is producing ideas that are both new and appropriate, mainly through divergent thinking.

Core facts

- **Problem solving: goal-directed thinking** to move from an **initial state** to a **goal state** when the way is blocked. It is **not unique to humans**: animals solve problems too (Thorndike's cats, Köhler's apes).
- **Parts of a problem**: initial state, goal state, the **obstacles**, and the operations (steps) allowed.
- **Well-defined problem**: clear start, goal and rules (a crossword, a maths sum). **Ill-defined problem**: goal or method unclear (writing a good essay, choosing a career).
- **Steps of problem solving** (textbook outline): **identify / define the problem** → **represent it and gather information** → **generate possible solutions** → **evaluate and choose** → **carry out** → **evaluate the result** (and go back if it fails). Polya's four steps of 1945 are in MAB-EI-03.
- **Trial and error**: trying responses until one works; **E.L. Thorndike** (puzzle-box cats, **1898**).
- **Insight**: sudden grasp of the whole solution after re-seeing the problem (the "aha" experience); **Wolfgang Köhler**, chimpanzee **Sultan** joining sticks and stacking boxes to reach bananas (*The Mentality of Apes*, German 1917; English 1925). Köhler was a **Gestalt** psychologist.
- **Algorithm**: a step-by-step procedure that **always gives the correct solution** if followed (a formula, trying every combination of a lock) but may be slow.
- **Heuristic**: a **rule of thumb** or short-cut; quick and usually works, but **does not guarantee** a solution.
- **Common heuristics: means-end analysis** (reduce the gap between present state and goal step by step, through **subgoals**: Allen **Newell and Herbert Simon**, General Problem Solver, late 1950s), **working backward** (start from the goal), **analogy** (use the solution of a similar problem), **hill climbing** (always take the step that seems to get closer).
- **Obstacles to problem solving: mental set, functional fixedness, lack of motivation**, confirmation bias, poor representation of the problem, emotional stress.
- **Mental set**: the tendency to keep using a method that worked before. It **speeds up** solving of similar problems but **blocks** new, simpler solutions. Classic study: **Abraham Luchins, water-jar problems (1942)**.
- **Functional fixedness**: seeing an object only in its **usual function**. Classic studies: **Karl Duncker's candle problem** (the box of tacks can be a candle holder; published 1945 in English) and **Norman Maier's two-string problem** (1931; a pair of pliers used as a pendulum weight).
- **Decision making**: choosing one course of action from **alternatives**, after judging their costs, benefits and chances. **Judgement**: estimating likelihoods and drawing conclusions from evidence.
- **Amos Tversky and Daniel Kahneman** (1974): judgement heuristics:

- **Availability:** judging how frequent something is by how easily examples come to mind (fear of flying after a crash in the news).
- **Representativeness:** judging by how much something resembles a typical case, ignoring base rates.
- **Anchoring and adjustment:** starting from an initial value and adjusting too little.
- **Framing effect** (Tversky and Kahneman, 1981): the same choice is judged differently when worded as a gain ("90% survive") or a loss ("10% die"). **Prospect theory** (1979): losses weigh more than equal gains (loss aversion). **Kahneman: Nobel Prize in Economics, 2002.**
- **Satisficing and bounded rationality:** Herbert Simon (see MAB-EI-03).
- **Creativity:** the ability to produce ideas or products that are **novel (original)** and **appropriate (useful, fitting the purpose)**. Both are needed; novelty alone is mere oddity.
- **Creative thinking is part of everyday life**, not only of art and science: it shows in **teaching, conversation, helping others, asking questions**, cooking, solving family problems.
- **Convergent vs divergent thinking** (J.P. Guilford): convergent = one correct answer; **divergent = many possible answers**; creativity draws mainly on divergent thinking.
- **Features of creative (divergent) thinking: fluency** (number of ideas), **flexibility** (variety of kinds of ideas), **originality** (unusual ideas), **elaboration** (developing an idea in detail). **Reproducibility is not one of them:** reproducing what exists is the opposite of creating.
- **Wallas (1926), four stages: preparation → incubation → illumination → verification.** Details, tests of creativity (Torrance, Baqer Mehdi, Passi), brainstorming (Osborn), lateral thinking (de Bono) and Getzels and Jackson are in EDU-ID-03.

Explained

1. Algorithm vs heuristic

Point	Algorithm	Heuristic
Nature	systematic, exhaustive rule	short-cut, rule of thumb
Result	correct answer guaranteed	answer likely, not guaranteed
Speed	slow when options are many	fast
Example	trying all 10,000 PINs of a 4-digit lock	trying birthdays first

Most real-life problems are solved by heuristics because a full algorithm would take too long; computers use algorithms where speed allows.

2. Trial and error vs insight

Point	Trial and error	Insight
Who	Thorndike (cats in puzzle box)	Köhler (chimpanzees)
Process	gradual, by stamping in the response that works	sudden reorganisation of the whole field

Point	Trial and error	Insight
Learning curve	slowly falling time taken	sudden drop; solution kept and transferred
School	connectionism / behaviourism	Gestalt

3. How mental set and functional fixedness block us. In Luchins's water-jar task, people who solved several problems with a long formula ($B - A - 2C$) kept using it even when a short one ($A - C$) would do; people without the practice series saw the short way at once. In Duncker's candle task, people given the tacks **inside** the box rarely thought of the box as a shelf; when the box was given empty, many more solved it. Both show that **past experience can help or hinder**: a set helps on similar problems and harms on different ones. Remedies: restate the problem, think of unusual uses, take a break (**incubation**), ask someone new.

4. Other obstacles. **Lack of motivation** (giving up early), **confirmation bias** (looking only for evidence that supports the first idea), **fixation on irrelevant details**, poor **representation** (a problem drawn as a diagram may become easy), anxiety and time pressure.

5. Steps and errors in decision making. A careful decision: list options → gather information on each → weigh consequences and probabilities → choose → review. In practice people rely on the judgement heuristics above, which produce biases: **overconfidence**, **sunk-cost** thinking (continuing because much has already been spent), the **framing** effect, **hindsight bias** ("I knew it all along"). Group decisions add **groupthink** (Janis; see MAB-EI-03) and **group polarisation** (groups move to a more extreme position than members held alone).

6. Creative thinking: the NCERT view. Creative thinking is not limited to a few geniuses; it varies by degree in everyone and can be **trained**. Its two hallmarks are **novelty** and **appropriateness**. It works with **critical (convergent) thinking**: divergent thinking generates many ideas, convergent thinking selects and checks the best. Barriers to creative thinking:

Barrier	Example
Habitual	mental set, doing it "the way it's always done"
Perceptual	functional fixedness, seeing only one side
Motivational	low interest, fear of failure
Emotional	fear of ridicule, anxiety
Cultural	stress on conformity, only one right answer

Ways to foster it: **brainstorming** (quantity of ideas, no criticism during the session), building a big list before judging, thinking of opposites and analogies, **lateral thinking**, keeping a notebook, taking time for **incubation**, and an environment of freedom and acceptance.

7. Creativity and intelligence. They are related but **not the same**. Intelligence tests stress convergent thinking; creativity tests stress divergent thinking. Research suggests a **threshold**: above-average intelligence (about IQ 120) is needed for high creativity, but above it the two are only weakly related. So a person can be highly intelligent but not very creative, and vice versa. (Getzels and Jackson's study: EDU-ID-03.)

Common traps

✗ "Heuristics always give the correct solution." ✓ Only an **algorithm** guarantees a correct solution; heuristics are short-cuts.

✗ "Problem solving is unique to human beings." ✓ Animals also solve problems (Thorndike's cats, Köhler's chimpanzees).

✗ "Mental set only hinders problem solving." ✓ It **speeds up** solving of **similar** problems; it hinders **new** ones.

✗ "Functional fixedness: Luchins; mental set: Duncker." ✓ **Mental set: Luchins** (water jars); **functional fixedness: Duncker** (candle) and Maier (two strings).

✗ "Insight learning: Thorndike." ✓ **Köhler** (Sultan); Thorndike = **trial and error**.

✗ "Availability heuristic = judging by resemblance to a type." ✓ Resemblance = **representativeness**; availability = **ease of recall**.

✗ "Creativity = novelty only." ✓ **Novelty + appropriateness**.

✗ "Reproducibility is a feature of creative thinking." ✓ The features are **fluency, flexibility, originality, elaboration**.

✗ "Creative thinking is seen only in art and science." ✓ It shows in everyday acts: **teaching, conversation, helping others, asking questions**.

✗ "Wallas: preparation, illumination, incubation, verification." ✓ **Incubation before illumination**.

Quick revision

- Problem solving = goal-directed thinking; initial state → goal state past obstacles; not unique to humans.
- Well-defined vs ill-defined problems; steps: define, represent, generate, evaluate, act, review.
- Thorndike: trial and error (1898); Köhler: insight, Sultan (Gestalt).
- Algorithm = always correct, slow; heuristic = rule of thumb, fast, no guarantee.
- Means-end analysis and subgoals: Newell and Simon; working backward; analogy.
- Mental set: Luchins water jars (1942); functional fixedness: Duncker candle, Maier two strings.
- Tversky and Kahneman (1974): availability, representativeness, anchoring; framing (1981); Kahneman Nobel 2002.
- Creativity = novel + appropriate; divergent thinking (Guilford): fluency, flexibility, originality, elaboration.
- Wallas 1926: preparation, incubation, illumination, verification.

- Creativity ≠ intelligence: threshold about IQ 120; tests and Getzels-Jackson in EDU-ID-03.