Cognition refers to mental activities and processes associated with thinking, knowing, remembering, and communicating information.

- Cognition can include reasoning, judgment, and assembling new information into knowledge.
- Cognition also supports these other psychological processes: attention, emotion, consciousness, perception, learning, memory, language, mental health, and social interaction.
A concept is a mental grouping of similar objects, events, states, ideas, and/or people, etc.

A concept can be represented and communicated by an image, or by a word such as “chair,” “party,” or “democracy.”
The Urge to Categorize

What was the percentage Asian in this blended Caucasian/Asian face?

What was the percentage Caucasian in the second blended face?

We tend to mold our memories and perceptions to fit pre-existing categories/concepts.
Problem Solving

Problem solving refers to the thinking we do in order to answer a complex question or to figure out how to resolve an unfavorable situation.

Trial and error involves trying various possible solutions, and if that fails, trying others.
• When it’s useful: perfecting an invention like the light bulb by trying a thousand filaments
• When it fails: when there is a clear solution but trial and error might miss it forever

An algorithm is a step by step strategy for solving a problem, methodically leading to a specific solution.

A heuristic is a short-cut, step-saving thinking strategy or principle which generates a solution quickly (but possibly in error).

Insight refers to a sudden realization, a leap forward in thinking, that leads to a solution.
Where’s the apple juice? Do I look on every shelf in the store, or do I search where there is similar stuff?

**Trial and error**
Wander around a supermarket randomly to find it.

**Algorithms**
Create a methodical path to make sure you check every single aisle.

**Heuristics**
Check only related aisles.
Trial and Error vs. Algorithms

To solve a word jumble, you can use:

Trial and error--randomly trying different combinations in no particular order

An algorithm (below)--carefully checking every single combination beginning with the letter “C” before moving on to a different starting letter.

1. C L O O Y S P H Y G
2. C O L O Y S P H Y G
3. C O O L Y S P H Y G...
To solve a word jumble, you can try a heuristic.

The problem with using trial and error to solve a word jumble is that there are 782,200 \((10!/(2!*2!))\) different ways to combine those letters. At least with the algorithm method, you are sure to get through them all without counting any of them twice.

However, it would help to use shortcuts/heuristics to reduce the options we need to try, such as:

1. putting a “Y” at the end.
2. thinking about where the other “Y” could go.
3. trying the “H” preceded by “C” and “S” and “P” before trying other combinations.
4. speculating that with so few vowels, the “O”s will probably not be together.

1. CLOOYSYPHYG

PSYCHOLOGY
Algorithms: Not Just Thoroughness

A father and a son are currently 40 and 10; when will the son be half the father’s age?

It might be tempting to use trial and error, but algebra gives us an algorithm, a single, certain, systematic path to the answer:

\[ x = \frac{1}{2} (x + 30) \]

\[ 2x = x + 30 \]

\[ x = 30 \]

Answer: when the son is 30, the father will be 60.
Three Methods of Problem Solving

Problem: given 100 one-foot lengths of fence, construct a rectangle that encloses the biggest area.

**Trial and error** approach: make a lot of rectangles

**Algorithm** approach: rectangle of unknown width

Area = Width times length = W times half of what’s left after making the widths, or $\frac{1}{2}(100-2W)$. We could graph all the different W’s and all the areas produced by different values for W, but instead of trial and area we graphed a function, Area = $W \times \frac{1}{2}(100-2W)$, or Area = $50x - x^2$, which makes a parabola, shown at the left. Notice that at $W = 25$, the area is at a maximum, and length = $\frac{1}{2}(100-2(25)) = 25$ also.

**Heuristic:** a square encloses the most area
Insight refers to a sudden realization, a leap forward in thinking, that leads to a solution.

- We say “aha” and feel a sense of satisfaction when an answer seems to pop into our minds.
- We also may laugh; joke punchlines rely on sudden insight.

Insight and the Brain

In one study, participants monitored by fMRI and EEG were asked, “which word will form a compound word with the words pine, crab, and sauce?”

What the brains did along with the “aha!” of getting the answer:

1. extra frontal lobe activity
2. experiencing the “aha!” moment and stating the answer
3. a burst of activity in right temporal lobe (shown here)
Obstacles to Effective Problem Solving

There are certain tendencies in human cognition which make it more difficult to find correct solutions to problems.

- Confirmation bias
- Fixation/mental set

Heuristics
(which help solve problems quickly but can lead to mistaken conclusions)
Confirmation Bias

- **Confirmation bias** refers to our tendency to search for information which confirms our current theory, disregarding contradictory evidence.

- Natural tendency: “If I’m right, then fact “C” will confirm my theory. I must look for fact “C.”

- Scientific practice: “If I’m right, then fact “D” will disprove or at least disconfirm my theory. I must search for fact “D.”

Studying Confirmation Bias: Peter Wason’s Selection Test

1. He gave the sequence of numbers “2, 4, 6.”
2. He asked students to guess his rule, and ask him whether other certain numbers fit the rule.

- The problem was not the students’ theory, but their strategy. If you think the rule is “even numbers,” what numbers would you need to ask him about to TEST rather than CONFIRM your theory?
Confirmation Bias Test

You are given the cards below, that have a letter on one side and a numeral on the other side.

Claim: if a card has a vowel on one side, then it has an odd number on the other side.

A  D  6  7

Which two cards would you turn over to find out if the claim is true?
Other Problem-Solving Habits

Mental set
The tendency to approach problems using a mindset (procedures and methods) that has worked previously.

Fixation
The tendency to get stuck in one way of thinking; an inability to see a problem from a new perspective.
Mental Set: Demonstration

What is next in these sequences?


If you are “primed” to use a certain problem-solving strategy, you can form a mental set that makes it harder to solve a new, similar problem.
Fixation

Problem: how can you arrange six matches to form four equilateral triangles?

When people struggle with this, what fixation is going on?

**Hint:** what assumption might be fixed in their minds?

Our mental set, perhaps from our past experiences with matchsticks, assumes we are arranging them in two dimensions.
The Nine-dot Problem

Use **four** straight lines to connect the **nine dots**. If you already know the solution, let others figure it out.
The Nine-dot Problem: Solution

Solving this requires escaping fixation by thinking outside the box. Literally.
The Nine-dot Problem
Can you use only THREE straight lines to connect these nine dots?
**Intuition**

- The human cognitive style of making judgments and decisions is more efficient than logical.
- The quick-acting, automatic source of ideas we use instead of careful reasoning is known as **intuition**.
- Using intuition to make a decision has some downsides, as we’ll soon see, but it also has some benefits.

**Making Quick Judgments and Decisions**

As with problem-solving, there are mental habits which make intuition-style judgments simpler and quicker, but may lead to errors:

1. the availability heuristic
2. overconfidence
3. belief perseverance
4. framing

All of these habits enable us to quickly make hundreds of small “gut” decisions each day without bothering with systematic reasoning.
The Availability Heuristic

We use the **availability heuristic** when we estimate the likelihood of an event based on how much it stands out in our mind, that is, how much it’s available as a mental reference.

**Example:** thinking that winning at a slot machine is likely because we vividly recall the times we’ve won before (thanks to bells, lights, and flowing coins)
Weighted Attention: Why We Fear the Wrong Things

The availability heuristic misleads us about whether a plane ride or a motorcycle ride is more dangerous. Of the many experiences available to us in forming our judgments, we tend to give more weight to some experiences than others.

- We know of both plane crashes and motorcycle crashes, but the plane crashes scare us more, and stand out more in the news and in memory.

Why do some dangers stand out more?

- Perhaps biology or natural selection predisposes us to fear heights, lack of control, and confinement... all of which are part of our image of a plane ride.
The Overconfidence Error

**Overconfidence** in judgments refers to our tendency to be more confident than correct.

We overestimate the accuracy of our estimates, predictions, and knowledge.

Examples:
- thinking you can put off work and still get it done well
- thinking you have test material mastered when you scan it and it feels familiar.
<table>
<thead>
<tr>
<th>Belief Perseverance Error</th>
<th>Overcoming Belief Perseverance</th>
</tr>
</thead>
<tbody>
<tr>
<td>“My mind is made up; do not confuse me with the facts.”</td>
<td>▪ You can’t cure someone else of belief perseverance. Just telling someone the “right” information won’t override it; people facing opposing information tend to become MORE polarized in their beliefs.</td>
</tr>
<tr>
<td>▪ Belief perseverance is <em>the tendency to hold onto our beliefs when facing contrary evidence.</em></td>
<td>▪ Instead, watch for this in yourself. Take opposing views and information seriously, always assuming that you could be wrong.</td>
</tr>
<tr>
<td>▪ We interpret information in a way that fits our beliefs. We might claim that the new information is wrong, biased, or just “doesn’t make sense.”</td>
<td></td>
</tr>
<tr>
<td>▪ Stereotypes are maintained by this error; people often disregard examples contradicting stereotypes by treating the new information as merely an exception, and not a challenge to the rule.</td>
<td></td>
</tr>
<tr>
<td>How to use it well</td>
<td>How it may have been adaptive</td>
</tr>
<tr>
<td>--------------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>We have seen that in complex situations, it helps to use careful reasoning to avoid mistakes made by intuitive judgments.</td>
<td>Judging quickly what to eat and what might kill us might have helped our ancestors survive long enough to reproduce.</td>
</tr>
<tr>
<td>However, research supports the idea that sometimes we need to let our unconscious mind do some work.</td>
<td>The times that our intuition was incorrect may not have been fatal; if humans avoided all red plants instead of poisonous berries, they might have been hungry, but still alive.</td>
</tr>
<tr>
<td><strong>Incubation</strong> refers to the power of taking a break from careful thinking, even to “sleep on it,” to allow leaps in cognition.</td>
<td></td>
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</tbody>
</table>
Do Other Species Think?

If thinking consists of understanding concepts, including words, numbers, and qualities, then...

- many creatures can memorize the names of many objects. Parrots can speak the names.
- birds can sort objects by shape, color, and type.
- Alex the African parrot could add numbers, and answer complex questions such as “what color bigger”? [“Tell me the color of the object that is the bigger of these two.”]
Do Other Species Think?

If thinking consists of **solving problems with insight**, devising behaviors that were not trained or rewarded, and putting strategies together in new combinations, then...

- chimpanzees do not say, “Aha,” but one showed sudden leaps in problem-solving. **After putting down a short stick that could not reach a fruit, he jumped up suddenly to use that short stick to reach a longer stick.**
Uses of Language

- We can hear about and understand phenomena we have never experienced.
- We can connect to people far away.
- We can make plans and have others carry them out.
- We can know what another person is thinking more directly than just by observing their behavior.
- We can store information.

What is language made of?

- **Phonemes** are the smallest units of sound (vowels and consonants).
- **Morphemes** are the units of meaning, i.e. words and meaningful parts of words such as suffixes, prefixes).
- **Grammar** refers to the rules for using words, including semantics, definitions, connotations, and syntax (how the order of words makes meaning).
How do we learn language?

Language Development

Language Development is an Amazing Process

- We acquire the use of 10 new words per day (on average) between ages 2 and 18.
- Children learn the basic grammar of language before they can add $2 + 2$.
- Most kids can recall words and meanings, and assemble words into sentences, while simultaneously following social rules for speaking and listening.
### How do we learn language?

#### Language Talents and Stages

<table>
<thead>
<tr>
<th>Age (months)</th>
<th>Talent/Behavior/Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>0-4 months</strong></td>
<td><strong>Receptive</strong> language: associating sounds with facial movements, and recognizing when sounds are broken into words</td>
</tr>
<tr>
<td><strong>4 months</strong></td>
<td><strong>Productive</strong> language: <strong>babbling</strong> in multilingual sounds and gestures</td>
</tr>
<tr>
<td><strong>10 months</strong></td>
<td><strong>Babbling</strong> sounds more like the parents’/household’s language</td>
</tr>
<tr>
<td><strong>12 months</strong></td>
<td><strong>One-word stage</strong>: understanding and beginning to say many nouns</td>
</tr>
<tr>
<td><strong>18-24 months</strong></td>
<td><strong>Two-word, “telegraphic”/tweet</strong> speech: adding verbs, and making sentences but missing words (“See bird! Ree book? Go park!”)</td>
</tr>
<tr>
<td><strong>24+ months, 2+ years</strong></td>
<td>Speaking <strong>full sentences and</strong> understanding complex sentences</td>
</tr>
</tbody>
</table>
Critical Periods

- According to one study with immigrants, beginning a language later made it harder to learn the pronunciation and the grammar of the second language.
- It is important to **begin appropriate language exposure/education early** so that language centers of the brain continue to develop.
- Language might never develop if not begun by age seven.
Sign language has the syntax, grammar, and complex meaning of any spoken language.

“Blindness cuts people off from things; deafness cuts people off from people.”—Helen Keller

Deaf and blind children can use complex adapted languages by using other senses that are heightened.

What happens if a deaf infant’s parents don’t use sign language?

Hint: critical period
Brain Damage and Language

**Aphasia:** an impairment in the ability to produce or understand language, usually caused by damage to the brain.

Examples of aphasia: having the ability to speak but not read, to produce words in song but not in conversation, and to speak but not repeat; or producing words in jumbled order.

Damage to Broca’s area leads to difficulty in putting words together in sentences or even speaking single words, although a person can sing a song.

Damage to Wernicke’s area leads to difficulty comprehending speech and producing coherent speech (not easily monitoring one’s own speech to make sure it makes sense).
Language and the Brain

How to read a word, steps 1 to 5

1. Visual cortex (receives written words as visual stimulation)
2. Angular gyrus (transforms visual representations into an auditory code)
3. Wernicke’s area (interprets auditory code)
4. Broca’s area (controls speech muscles via the motor cortex)
5. Motor cortex (word is pronounced)

Remember: language functions are divided in the brain.
Do Other Species Use Language?

- **Receptive** language for individual human words seems to exist for a few species; dogs can follow hundreds of commands.

- **Productive** language: many animals have “words”: sounds, gestures, dances (bees) to communicate information, including different “words” for different objects, states, and places.

Can other species communicate with us through language?

- Washoe the chimpanzee learned to use 245 signs to express what she wanted or noticed.

- Fellow chimpanzees learned signs from each other without training and without rewards.

- A deaf N.Y. Times reporter visited Washoe and said, “I realized I was conversing with a member of another species in my native tongue.”
Is the chimp signing really language?

- Washoe seemed to combine words in new ways to convey meaning; Washoe used the phrase “apple which is orange” for an orange (fruit).
- Chimps do not pick up words as easily as human children.
- Chimp word production lacks syntax, but a bonobo correctly understood “make the dog bite the snake.”

Signing “baby”
For example, Benjamin Whorf (1897-1941) proposed that because the Hopi do not have past tense forms for verbs, it is hard for them to think about the past.

Can you think about something that you do not have a name for? If so, does that disprove linguistic determinism?
Language’s Influence on Thought

Does language shape emotions or reflect them?
- Speaking in Japanese provides many extra words for interpersonal emotions such as sympathy and empathy, which Americans might have trouble differentiating.
- Speaking English gives us many words for self-focused emotions, such as sadness.

Do language differences shape personality differences?
- Bilingual people appear to have different personality profiles when describing themselves in different languages.
- “Learn a new language and get a new soul.”—Czech proverb.

Color Perception
- We use our native language to classify and to remember colors. Different languages may vary in where they put the separation between “blue” and “green,” or they may not have separate words for these colors.
- Which squares are green? teal? blue?
Languages Improve Thinking

*The Bilingual Advantage*

- People who are bilingual have numerous brain connections and neural networks.
- They also have a hidden talent, the ability to suppress one language while learning another.
- This ability tends to go along with other forms of executive control, such as resisting distraction and inhibiting impulses.