Language is defined as a system for communication with others using signals that are combined according to rules of grammar—**syntax**—and convey meaning (**semantics**).

Grammar is a set of rules that specify how the units of language can be combined to produce meaningful messages. *Note the difference between grammar and meaning.*

Human language may have evolved from other signaling systems, as the development of human language centres in the brain and the evolution of the larynx are new to the planet. See Web Article 3 for more details on the larynx.

Even more interesting is the age at which babies can learn sign language, some as early as 6 months. [https://www.today.com/parents/baby-sign-language-basics-when-start-how-teach-it-t156990](https://www.today.com/parents/baby-sign-language-basics-when-start-how-teach-it-t156990)

And finally, worker bees can be taught to learn and use abstract symbols, so some humility is necessary when we think we are the only creatures on the planet that can communicate in symbols. [https://www.scientificamerican.com/article/exploring-consciousness/](https://www.scientificamerican.com/article/exploring-consciousness/)

**Phonemes, Morphemes & Visemes**

Basic characteristics and components of language: phoneme, morpheme, viseme. A **phoneme** is the smallest unit of sound that is recognized as speech, rather than noise. A **morpheme** is the smallest **meaning** unit of language.

To understand the difference between phonemes and morphemes, study Fig. 9.1 A sentence—the largest unit of language—can be broken down into progressively smaller units: phrases, morphemes, and phonemes. In all languages, phonemes and morphemes form words, which can be combined into phrases and ultimately into sentences.


Every language has a set of phonological rules that indicate how phonemes can be combined to produce speech sounds. Morphological rules indicate how morphemes can be combined to form sounds. There are two classes of morphemes: **content morphemes** refer to things and events, or affixes that when added to a base word, change its meaning or part of speech; **function morphemes** tie sentences together, they can also include affixes that indicate the grammatical role of a base word, such as those required for plurals.

Function morphemes make human language grammatically complex enough to permit us to express abstract ideas, rather than simple point to concrete objects.

Try it your self: google 'content morpheme example' and 'function morpheme example'. A sample result: [https://study.com/academy/lesson/morphemes-examples-definition-types.html](https://study.com/academy/lesson/morphemes-examples-definition-types.html)
Syntax

**Syntactical** rules indicate how words can be combined to form phrases and sentences. Every sentence must contain one or more nouns, which can be combined with adjectives or articles to create a noun phrase. A sentence must also contain one or more verbs, which can be combined with noun phrases, adverbs or articles to create a verb phrase.

In everyday language, syntax usually stumps grammar; for example we often speak in broken or partial sentences, because the listener understands our syntax.

https://neurosciencenews.com/linguistics-complete-sentences-3482/

Here is an important excerpt: one region of the brain, the left angular gyrus, responds in a special way to the presentation of incomplete predictable words. This structure in the parietal lobe of the human brain supports the interpretation of meaningful sentences and is considered an important sub-area of the neural language network. (Scharinger, 2016)

**Morphological Rules**

Morphological rules indicate how morphemes can be combined to form words. Some morphemes, such as **content morphemes** and **function morphemes**, can stand alone as words. Content morphemes refer to things and events, while function morphemes serve grammatical functions, such as tying sentences together.

**Syntactical Rules**

Syntactical rules indicate how words can be combined to form phrases or sentences. A sentence can be constructed in a way that obeys syntactical and other rules, yet be entirely lacking in meaning or **semantics**. Study Fig. 9.2 for the next exam.

Try it yourself: google "random sentence generator".

**Deep structure** refers to the meaning of a sentence; **surface structure** refers to how a sentence is worded. Misunderstanding one structure for another can have consequences in therapy and counseling.

For more on this topic, visit:


There will be 'deep structure versus surface structure' questions on the next exam.
Language Development

Three characteristics of language development are worth bearing in mind: (1) children learn language at an astonishing rate [1-year-old = 10 words, 5-year-old = 10,000 words.]; (2) children make few errors when learning to speak, and those errors are usually overgeneralizations; (3) a child's passive mastery of language develops faster than their active mastery.

Distinguishing Speech Sounds

Within the first six months of life, infants lose their ability to hear all the contrasting sounds of human language. For example Japanese infants cannot distinguish between l and r. Eimas et al., 1971 rigged a pacifier so that whenever the infant suck on it, a tape player would broadcast a 'la la' sound. After a while, they began to lose interest, and sucking frequency declined to about half its initial rate. The tape was then switched to 'ra ra'; the Japanese infants began sucking again with vigour, indicating they could hear the difference.

Babbling

Infants can distinguish between speech sounds, but they cannot produce them reliably. Babbling is defined as combining vowels and consonants that sound like real syllables but are meaningless (lacking both syntax and semantics). Regardless of the languages they hear spoken, all infants go through the same babbling sequence: d and t appear before m and n. Goldstein et al, 2010, has shown that babbling is a natural part of the language development process, a signal that the infant is in a state of focused attention and ready to learn. Delayed babbling or the cessation of babbling merits testing for possible hearing difficulties. Babbling problems can lead to speech impairment but they do not necessarily prevent language acquisition.

Deaf Infants

Deaf infants do not babble as much, but those whose parents using American Sign Language (ASL) do start babbling with their hands around the same time that hearing infants babble vocally, between 4 and 6 months. (Pettito & Marentette, 1991). Their babbling consists of the sign language syllables that are the fundamental components of ASL.
**Language Milestones**

**Fast mapping**: children learn to map a word onto an underlying concept after only a single exposure, enables them to learn at a rapid pace. (Kan & Kohnert, 2008).

<table>
<thead>
<tr>
<th>Average Age</th>
<th>Language Milestone</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4 months</td>
<td>Can tell the difference between speech sounds (phonemes) that are not distinguished in their native language. Cooing, especially in response to speech.</td>
</tr>
<tr>
<td>4-6 months</td>
<td>Babbles consonants</td>
</tr>
<tr>
<td>6-10 months</td>
<td>Understands some words and simple requests. Can no longer reliably distinguish sounds that are not in their native language.</td>
</tr>
<tr>
<td>10-12 months</td>
<td>Begins to use single words.</td>
</tr>
<tr>
<td>12-18 months</td>
<td>Vocabulary of 30 to 50 words. (simple nouns, adjectives, and verbs)</td>
</tr>
<tr>
<td>18-24 months</td>
<td>Two-word phrases ordered according to syntactic rules. Vocabulary of 50 to 200 words. Understands rules.</td>
</tr>
<tr>
<td>24-36 months</td>
<td>Vocabulary of about 1000 words. Production of phrases and incomplete sentences.</td>
</tr>
<tr>
<td>36-60 months</td>
<td>Vocabulary grows to more than 10,000 words, production of full sentences, mastery of grammatical morphemes (such as -ed for past tense) and function words (such as the, and, but) Can form questions and negations.</td>
</tr>
</tbody>
</table>

**Fast mapping** is the process whereby map a word onto an underlying concept after only a single exposure, enables them to learn at a much more rapid pace. (Kan & Kohnert, 2008).

**Telegraphic speech** is devoid of function morphemes and consists mostly of content words. Despite this limitation, these 'two-word' sentences follow the grammatical rules of the language that the children (as young as two-year-olds) are learning to speak.

**Grammatical rules** form when young children express the particular sounds that they want to communicate. But by the age of 4 or 5 these same children will be using the incorrect form of these verbs. This is because they overgeneralize. These errors show that language acquisition is not simply a matter of imitating adult speech, all done without explicit awareness of grammatical rules particular to a language or culture.

A **30-million word gap** exists between families of high socioeconomic status [SES] and those of low. Hirsch-Pasek et al., (2015) suggest that the negative consequences of this can be countered by the quality of communication between parents and children in low SES families.
Language Development and Cognitive Development

Nearly all infants begin with one-word utterances before moving on to telegraphic speech (two words) and then to simple sentences that include function morphemes. This orderly progression is most likely the result of general cognitive development that is unrelated to experience in a specific language. (Wexler, 1999).

Snedeker et al., (2007) examined preschoolers ranging from 2 1/2 to 5 1/2 years old, 3 to 18 months after they were adopted from China. Parents were given strict rules for periodically recording language samples in their homes. The main result: language acquisition in preschool-aged adopted children showed the same orderly progression of milestones that characterizes infants. These milestones reflect experience with English rather than general cognitive development. However, the adopted children did add new words to their vocabulary more quickly than infants did.

Snedeker et al., (2012) Adopted preschoolers acquire words that refer to the past or the future—tomorrow, yesterday, before, after—much more quickly than do infants.

Theories of Language Development:

Behaviourists posit that infants learn language through shaping by successive approximations, that is, they interact with their caregivers and this forms their language sets. This theory has three weaknesses: (1) parents do not spend much time teaching their children to speak grammatically; (2) children generate more grammatical sentences than they hear, that is they learn the rules for generating sentences; (3) the errors children tend to make when learning to speak tend to be overgeneralizations of grammatical rules.

Nativists This theory holds that language developments is best explained as an innate, biological capacity. Chomsky (1957) posits that the brain comes equipped with a language acquisition device, or a collection of processes (we call them neural networks now) that facilitate language learning. Language capacity can be distinct from other mental capacities. People can be born with genetic dysphasia a syndrome characterized by an inability to learn the grammatical structure of language despite having otherwise normal intelligence. Varga-Khadem has noted this syndrome tends to run in families and a single dominant gene has been implicated in its transmission.

Back to Chomsky: the biological predisposition to acquire language helps to explain why newborn infants can be make contrasts among phonemes that occur in all human languages, even phonemes they have never heard spoken. If we learned language through imitation, as behaviourists theorize, infants would only distinguish the phonemes they actually heard. Also consistent with the nativist view is that language can be acquired only through a restricted period of development, known as the critical period, or the event window. Once puberty is reached, acquiring language becomes increasingly difficult. Johnson & Newport (1989) report that the proficiency with which immigrants to America spoke English depended not how long they had lived in the United States, but on their age at immigration. Bloch et al., (2009) report that fMRI shows that acquiring a second language early in childhood (between 1 and 5) results in a very different representation of that language in the brain than does acquiring at after 9.

Pyers et al. (2010) posits the interaction between biology and experience. Nicaraguan deaf children developed their own sign language, and it evolved as younger children added nuances of gesture to the existing grammar, syntax and semantics.
**Language Development & The Brain**

Neuroscientists study people with brain damage--lesions--in order to better understand how the brain normally operates. When **Broca's area** (left frontal cortex) is damaged, people have a hard time producing sentences. When **Wernicke's area** (left posterior temporal cortex) is damaged, people can produce sentences, but they are meaningless.

As the brain matures, such brain areas become more specialized for language and increasingly exposed to **aphasias**, difficulty to produce or comprehend language.

**Broca's area aphasias**: increasing comprehension difficulty as grammatical structures get more complex. Typically they speak in short, staccato phrases that consist mostly of **content morphemes**. **Function morphemes** are usually missing and grammatical structure is impaired.

**Wernicke's area aphasias**: patients can produce grammatical speech, but it tends to be meaningless, and they have difficulty comprehending language.

In normal language processing, Wernicke's area is highly active when we make judgments about word meaning. And not just auditory: Japanese persons who suffer from Wernicke's aphasias encounter difficulties in writing and understanding the symbols that represent speech sounds, but **not** pictographs (Sasanuma 1975).

**Bilingualism & The Brain**

(Craik & Luk, 2012) report that bilingual individuals benefit from exerting executive control in their daily lives when they attempt to suppress the language that they do not want to use. Bilingual individuals tend to have a later onset of Alzheimer's disease the monolingual individuals, perhaps reflecting that during their lives they have built up a greater amount of back-up cognitive ability (Schweizer et al. 2012). These findings are consistent with research showing that a second language produces lasting changes in the brain (Stein et al., 2009).

Mechelli et al., 2004 report that learning a second language early increases the density of grey matter in the **lower left parietal region** in the brain. This is the same area of the brain that is activated during verbal fluency tests.

Linguistic Relativity Hypothesis. Whorf (1956) language shapes the nature of thought. He developed this theory while studying the Inuit, who have 78 separate terms for our single word 'snow'. Elanor Bosch (1973) testing this hypothesis with the Dani of New Guinea. They have only two words for colours: 'dark' and 'light'. They learned , however, shades of colour just as well as English-speakers can. Winawer et al., (2007) used 20 patches of blue from light to dark, and reported that in a colour matching test, Russian speakers could respond more quickly using Russian terms than English speakers could using English terms.

Language & Time: Casasanto & Boroditsky (2008) They asked subjects to move blocks to indicate the passage of time. English speakers moved the blocks more quickly horizontally; Mandarin speakers moved them more quickly vertically. When English speakers learned the Mandarin terms, they moved the blocks more quickly in a vertical direction, indicating that a change in language can predict a change in behaviour.
Concepts & Categories.

Concept: a mental representation that groups or categories shared features of related objects. Concepts are also language based: "How can a bean-bag chair (no legs) have anything in common with the Chair of Peter? (in John Lateran in Rome, no one ever sits on it.).

A necessary condition is something that must be true of the object in order for it to belong to the category. Eg: All dogs are mammals, so be categorized as a dog, an animal must be a mammal.

A sufficient condition is something that, if it is true of the object, proves that it belongs to the cateryory. Poodle is a sufficient condition for the category dog.

Family resemblance theory: members of a category have features that appear to be characteristic of category members but may not be possessed by every member. Members of the bird family have feathers and wings. Anything with these feature is likely be considered a bird. Family resemblance data tend to cluster, and 'cluster analysis' is used to prove a new specimen a member of a category. This is how the connection between birds and dinosaurs was built.

Prototype theory: the 'best' or 'most typical' member of a category. Whichis more of a prototypical dog: a German shepherd or a poodle? How does a chihuahua fit?

Exemplar theory: we make categorical judgments be comparing a new instance with stored memories for other instances of the category. We match the prototype to the specifics, and it changes our perceptions. For example, most new illustrations of velociraptors now include feathers.

Marsolek, (1995) reported that participants classified prototypes faster when the stimuli were presented to the right visual field, meaning that the left hemisphere received the input first. Exemplars were perceived more quickly when the information was presented to the left visual field (or right hemisphere). Left hemisphere = prototypes; right hemisphere= exemplars.

Martin & Caramazza reported proof of category-specific deficits. Some brain-damaged subjects could recognize human-made objects, but not living things and foods. Warrington & Shallice (1984) reported patients with the opposite condition. This is an inability to recognize objects that belong to a particular category, although the ability to recognize objects outside that category is undisturbed. Damage to the frontal part of the left temporal lobe: can't identify humans; Damage to the lower left temporal lobe: can't identify animals. (Damasio et al., 1996)
Rational choice theory: we make decisions by determining how likely something is to happen, judging the value of the outcome and then multiplying the two. Selecting the option with the highest expected value seems straightforward, but we often do not.

We are more likely to think in terms of frequency (how often something happens) than probability (calculating if it will happen). Eddy (1992) discovered that physicians predicting possible evidence of breast cancer declared the probability to be 75%, when calculated the probability was 8%. The problem: taking too much information into account when making their decision. If a frequency approach was used, 46% of the physicians got the correct calculated answer. (Hoffrage & Gigerenzer, 1998).

**Availability bias**: items that are more readily available in memory are judged as having occurred more frequently. Memory strength and frequency of occurrence are directly related. Frequently occurring items (more neural real-estate) are remembered more easily than infrequently occurring ones. Better memory because of better familiarity.

**Heuristics**: a fast and efficient strategy that may facilitate decision making but does not guarantee that a solution will be reached. Also known as 'rule of thumb'

**Conjunction fallacy**: people think that two events are more likely to occur together than either individual event. The fallacy: with each new additional bit of information, the probability that all the facts are simultaneously true of a person increases. In fact, the probability decreases dramatically. The intersection of all the possibilities is smaller than the area of any one possibility alone.

**Representative heuristic**: a mental shortcut making a probability judgment by comparing an object or event to a **prototype** of the object or event. Example: Harry loves to read and smoke pipe, is quiet and unassuming. Is he more likely to be truck driver or a university professor? Image or statistics?

Prospect theory: Tversky & Kahneman (1992) reported that people choose to take on risk when evaluating potential losses and avoid risks when evaluating potential gains. Why? People tend to simplify available information, and choose the prospect that offers the best value. People wish to increase **expected utility** (maximizing value); they give greater weight to outcomes that seem like a sure thing, the **certainty effect**.

**Frequency format hypothesis**: Our brains and minds have evolved to notice how frequently things occur, not how likely they are to occur. We interpret, process, and manipulate information about frequency with comparative ease because that is the way quantitative information usually occurs in natural circumstances.

Probabilities and percentages are evolutionarily speaking, recent developments emerging in the mid-seventeenth century. Hasher & Zacks, (1984) report that people can track frequencies virtually effortlessly and flawlessly. Infants as young as six months can tell the difference in displays that differ in the number of items present (Waldmann, 2000).
Bechara et al., (1997) reported that: in a study of risky decision making, researchers compared healthy control's choices to those made by people with damage to the **prefrontal cortex**. Participants played a game in which they selected a card from one of four decks. Two of the decks were made up of riskier cards, that is, cards that provided large payoffs or large losses. The other two contained safer cards--those with much smaller payoffs and losses. At the beginning of the game both groups chose cards from the two decks with equal frequency. Over the course of the game, the healthy controls avoided the bad decks and showed large emotional responses [SCRs, or skin-conductance responses] when they even considered choosing a card from a risky deck. Participants with prefrontal brain damage, on the other hand, continued to choose cards from the two decks with equal frequency and showed no evidence of emotional learning and eventually went bankrupt.

Johnson, Xiao et al., (2008) reported on Chinese adolescents with binge-drinking problems. Offenders who performed badly on the Bechara gambling test were much more likely to repeat committing DWI offences than those who performed well on the gambling task.

To sum up, neuro-imaging studies report greater activation in the prefrontal cortex, which is correlated to better task performance in healthy individuals. (Lawrence et al., 2009).
Problem Solving

Means-end analysis: the process of searching for the means or steps to reduce differences between the current situation and the desired goal.

Normally problems are solved by clearly defining the subgoals, those necessary steps to reach your solution.

Analogical problem solving: solving a problem by finding a similar problem with a known solution and applying that solution to the current problem.

Usually, the biggest hurdle is that the problem is ill-defined, and therefore one does not know immediately what skills and strategies to apply. Here is an example: "How can you make two and two equal five?" (Look down this page for the answer)

For example, a tumour must be removed. If the full X-ray dose is used in one application, the patient will be even sicker than before. The solution is a military one: infiltrate. Use several smaller X-ray doses that do not harm adjacent tissue. Studies have shown that only 10% of participants spontaneously generated the correct solution. If the participants read the military strategy, 30% got the right answer. If allowed to read more than one analogous story, participants solved the problem correctly 75% of the time. (Gick & Holyoak, 1980).

Creativity and Insight. Genius often lies in restructuring the problem in a way that allows a more simple and elegant solution than slogging through a tedious task. Bowers et al., (1990) suggests that sudden insightful solutions may actually result from unconscious incremental processes.

What stops us from having insights? Functional fixedness--the tendency to perceive objects and processes as fixed or static-constricts our thinking. Look back at the 'two and two' problem. Did I say that it could only be solved by a first-order equation? No. Here is the solution: just add zero.

\[2^2 + 2^0 = 5\]

Sudden insight and the Brain

Subramaniam (2009) reported that being in a positive mood was associated with increased activity in the anterior cingulate cortex (the purple-shaded area) in the moments before people solved a problem by sudden insight. This suggest that this change increases one's ability to create associations needed for problem solving.
Reasoning and the Brain

To sum up: reasoning is a mental activity that consists of organizing information or beliefs into a series of steps in order to reach a conclusion; practical reasoning is directed toward action; discursive reasoning is directed toward arriving at a belief.

Research using fMRI (Goel, 2007) shows that different types of reasoning activates different brain regions. Areas within the parietal lobe were especially active during logical reasoning that is not influenced by prior beliefs whereas an area within the left temporal lobe showed enhanced activity during reasoning influenced by prior beliefs.