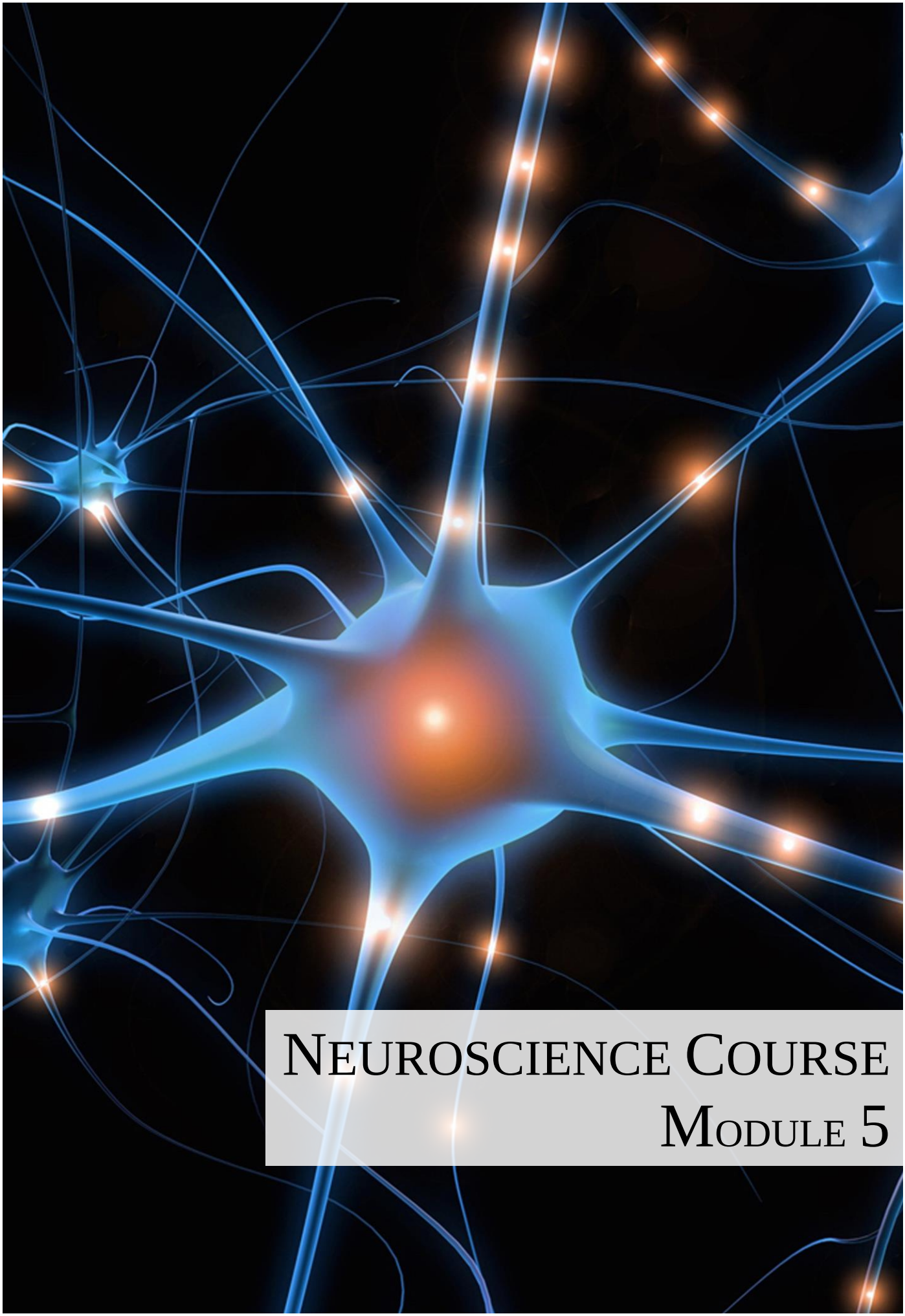


Neuroscience Course
Module 5

Language rightly deserves to be considered the foundation of human civilization. Paleontology, linguistics, genetics, physiology and anatomy are all scientific disciplines that take a close interest in the emergence and development of language. Indeed, it is impossible to imagine the evolution of our civilization without language.

Language or communication?

When discussing the concept of language, the first question that arises is as follows: can we consider the terms 'language' and 'communication' as equal? For many people, the answer is yes, and for good reason: language involves communication. However, we should take a completely different perspective on the question.

Using language amounts to communicating, but we do not necessarily need language to communicate. Verbal or otherwise, language is just one of many communication tools. Animals and even plants communicate without speaking; they use other forms of expression. Communication involves transmitting information. It can be tactile, olfactive, visual, chemical, aural or acoustic.

Plants, for example, use various strategies to attract or to protect themselves. Some carnivorous plants give off a scent of rotting meat to attract insects, which they then eat. Cacti and roses have also developed spines and thorns to ward off predators. Animals use similar strategies.

Glowworms use luminescent signals to attract sexual partners, while crickets use sound-based signals. Ants use tactile signals to find each other while moving around and assess the state of their environment. Many animals urinate to mark their territory and thus make their peers understand that they are not welcome. As such, there is a vast range of communication tools.

Thus, communication is like a form of engagement and transmitting a message. The principle of duality is not included. The party transmitting the information is not overly interested in what the party receiving it thinks. They are simply stating a fact. As such, the other can consider it or ignore it, if they think they can afford to. Communication is the expression of a state of affairs that may potentially lead towards an exchange of information.

Language, meanwhile, introduces a new concept: that of reciprocity. We use language not only to transmit information, but also to understand what those around us say or think about the message sent. Language therefore involves a principle of interaction between the different individuals using it.

When we go somewhere, we are not only interested in the message we want to transmit; we also pay attention to the information and messages given out by those around us. This phenomenon can often be observed in shops. However much we might like an item, we will rush to put it back if people around us have criticized it. As such, this goes beyond the simple concept of a signal.

Thus, with regard to language, we are referring simultaneously to communication, discovery, transmission of information, and also learning. This does not mean that reciprocity cannot be observed during communication. Dogs, cats, elephants and other animals communicate through what we could interpret as a language. They produce sounds, and even ultrasounds and infrasounds. They have a relatively rich social life and manage to transmit all the important information that is necessary for their existence to each other, but this is far from how humans' spoken language works.

Language makes it possible to transmit sexual signals or danger signals, but also emotions and thoughts. So, what are the foundations of language? What is it used for? How do we understand and structure it? What are the different types of language? How can we help people who have communication difficulties?

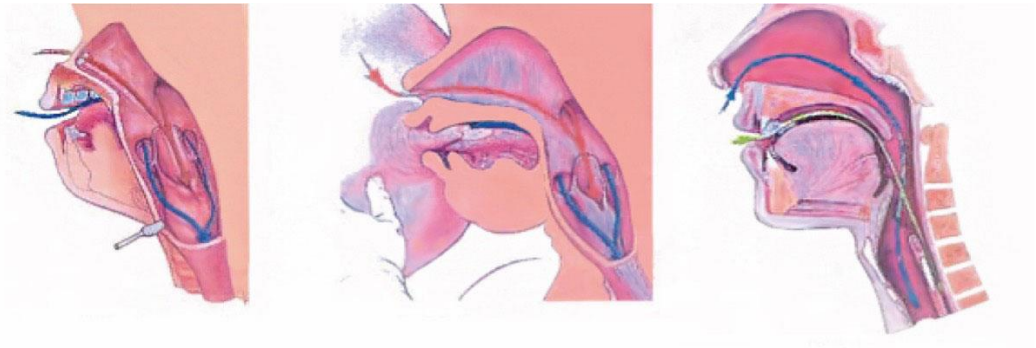
Foundations of language

When talking about the foundations of language, we should specify that we are referring to spoken language. We will limit ourselves to spoken language for the time being because this is the very first step. Written language can only come after this phase. Understanding the foundations of spoken language involves studying the functional anatomy of language, as well as the neuropsychological and neurophysiological aspects.

✪ Functional anatomy of language

The brain and vocal apparatus form the foundations of spoken language. The vocal apparatus can be likened to a musical instrument and, like with any other instrument, its owner has to practice in order to master it perfectly. This comparison with a musical instrument also works to explain how it functions.

✪ Differences in the vocal apparatus



Oral cavity of an adult chimpanzee | Oral cavity of a 9-month-old child | Oral cavity and larynx of an adult man

The diagram above helps to illustrate why spoken language is primarily human. The vocal apparatus of a chimpanzee displays the clear differences that exist between human anatomy and that of animals.

The vocal apparatus in humans is like an amalgamation of stringed and woodwind instruments. The lungs act as the wind instrument, while the vocal cords can be thought of as stringed instruments. Fixed between the hyoid cartilage and the arytenoid cartilages, these cords are activated by the pharynx, which acts as an echo chamber. How this element reacts depends on the actions being performed:

- Swallowing: During this phase, one of the body's primary functions is to prevent the food consumed from ending up in the windpipe, because if it does, it will have direct access to the

lungs (which is not desirable). The larynx lifts, thus allowing the epiglottis to fold back down and block access to the trachea.

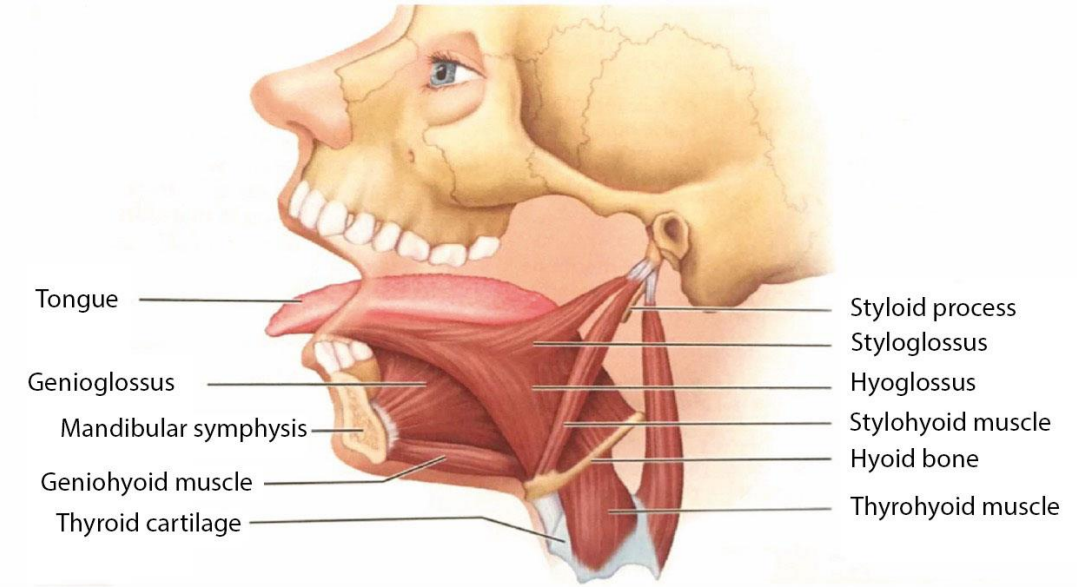
- Respiration: The movement of the larynx is the opposite to that in the previously mentioned action. This time it lowers, which leads to the epiglottis opening in parallel. These two actions cause the vocal cords to separate, which facilitates the circulation of air at the same time.
- Speech: The air expelled by the lungs reaches the larynx and is projected directly onto the vocal cords, which then start to vibrate. The pharynx behaves like an echo chamber and amplifies the sound emitted by the vocal cords. However, the process is far from being over. To achieve the final result, the tongue, teeth and lips also have to regulate the release of sounds.

In addition to the larynx, pharynx and vocal cords, another element plays an important role in the production of spoken language: the hyoid bone. This midline bone is completely separate from the skeleton, but is connected to it by the mylohyoid, geniohyoid, digastric, stylohyoid, omohyoid, sternocleidohyoid, thyrohyoid, sternohyoid and hyoglossus muscles.

It regulates swallowing, chewing, phonation and, of course, respiration. The bone, but also its position in relation to the rest of the skull, determines the individual's capacity to express themselves. From birth to adulthood, its position changes gradually.

At birth, it occupies essentially the same position as it does in primates. This limits the child's phonatory capacities, but allows them to perform certain actions without any risk. This applies in particular to the ability to eat while breathing through the nose. As the position of the bone changes, this task will become increasingly complex. In adults, it will simply be dangerous, because it may lead to food getting into the windpipe and cause choking as a result.

The hyoid bone, which serves as a support to the organs that make up the vocal apparatus, starts to change position from the third month after birth. The larynx lowers gradually from the third or fourth month and reaches its definitive position at the age of 2. During this timeframe, the child develops its ability to express itself.



The diagram above represents the position of the cranial bones. We will focus particularly on the position of the styloglossus muscle. The gradual development of this muscle explains why young children are incapable of pronouncing certain letters.

However, these organs can only help to produce sounds. Language processing and management are carried out by the brain. Generally speaking (i.e., for the majority of people), language processing takes place in Broca's and Wernicke's areas.

In most people, the majority of brain activity connected to language takes place in the left side of the brain. However, some people use both sides equally, mainly left-handed people, whose brain function is atypical. Although it is not as important in the functioning of language as the dominant hemisphere, the non-dominant hemisphere is involved in many language-related operations.

In most right-handed people, between 92% and 96%, spoken language is controlled by the left hemisphere. The situation is more complex in left-handed people. For a long time after the Wada test was developed, the scientific community thought all left-handed people's brain function was atypical. They even avoided selecting them to participate in scientific studies.

However, the work of individuals like Bernard Mazoyer shed new light. They proved that 70% of left-handed people had the same brain function as right-handed people (dominant left hemisphere), around 15% used their left hemisphere as much as their right, and that for the remaining 15%, the right hemisphere was responsible for managing spoken language.

For decades, the management of language was attributed to just two zones:

- Wernicke's area, located in the superior temporal gyrus and responsible for the formulation and understanding of words;
- Broca's area, which is found in the inferior frontal gyrus and is responsible for producing words.

However, more in-depth studies, specifically of brain imaging sessions, revealed the importance of another zone: the inferior palatal lobule, primarily in the angular gyrus, which is also known as the Geschwind territory. Its purpose is to assimilate all the properties to every word to facilitate understanding.

Studies that assessed semantic processing of words reported an activation of the angular gyrus for the repetition of words in relation to the repetition of syllables. They also showed that the left angular gyrus is more active during semantic word-related tasks than during phonological tasks.

Indeed, different regions of the brain in the left and right hemispheres were identified later to assist specific linguistic functions. Despite the fact that there are hundreds of studies on the subject, it is still difficult to describe the neural basis of language and speech. Thanks to the scientist Brodmann, a pioneering figure in mapping the human brain, new neuroarchitectonic approaches have provided detailed information on the subdivisions of the regions that make up the linguistic network.

So, how do we express ourselves? How does the phonation process take place? In short, everything starts in the brain, or more precisely in Wernicke's area: this is where the words we wish to transmit are identified and selected. The information then moves into the Geschwind territory before being transferred into Broca's area, which then gives the final orders to the vocal apparatus.

The lungs trigger the movement of the vocal cords, which leads to the production of sounds, the intensity of which varies based on air pressure, but also the frequency of the vibration of the cords themselves. The pharynx acts as an echo chamber, then the tongue, teeth and soft palate are responsible for modulating the sounds emitted. These are permanent resonators; others, like the nasal cavity, only participate in the process under certain conditions.

Language is a complex cognitive function that seems to be sensitive to different kinds of information, some of which is linguistic but some of which is not. It interacts with other cognitive functions like attention and memory; in some respects, these cognitive functions are integrated into language processing itself.

Neurophysiology of language

The neurophysiology of language studies language in all its aspects, but only from the perspective of brain function. This makes it possible to both analyze the zones involved in the reproduction of language, whether spoken or written, and diagnose conditions related to language and ensure they are supported when they are dependent on brain function. It is particularly important to understand these processes in patients suffering from brain injuries.

Note, however, that the contemporary perception of the neuropsychology of language has evolved. We will ignore the 19th-century vision, which was based on the principle that the production of language was linked exclusively to the functioning of the language centers. Nowadays, the neurophysiology of language also takes into consideration all the neural structures that are involved in the steps in language processing and communication in general.

Initially, the area of study was spoken language in general, with no classification. The neurophysiology of language encompasses phonology, semantics, phonetics, pragmatics, morphology and syntax. All these phases of processing can be affected by malfunctions and disorders.

Should we conclude that the position of the different centers is no longer valid? Not quite! Given that the management of language does not take place exclusively in these two centers, the classification has simply become more complex than it was in the past. Better yet, we now analyze the interactions between the two brain hemispheres.

Beyond the physiological aspect, this science also focuses on the cognitive aspect of language, which rests on three principles:

- modularity, which should be seen as a ‘complex information processing system’: it is split into several subsystems and blocks of data, all of which have functional autonomy;
- fractionation, which describes the brain’s ability to keep the function of all these operating blocks active in the event of injury, with the exception of the one that was damaged: the component that was destroyed does not necessarily (or indeed at all, sometimes) influence the rest of the processes despite having been linked to them;
- transparency, which can be assessed in patients suffering from brain injuries: the performances they display during or after rehabilitation can be the result of treatment of just one operating block, or of several modules.

These three principles are generally studied in patients with brain injuries, because they facilitate targeted analysis of all the components in the cognitive architecture of an individual in good health. In other words, analyzing deficiencies in a brain-damaged patient gives a more precise image of the brain architecture in general. Of course, it also highlights the associations and dissociations between the different processes.

Mechanisms of language development

In this section, we will examine the mechanisms involved in the development of both spoken and written language. This is a long process that is heavily influenced by the environment in which the baby grows up.

✪ Development of spoken language

In the evolution of spoken language, we generally distinguish between two stages: the prelinguistic stage and the linguistic stage.

✦ The prelinguistic stage

Although they are unable to speak at birth, babies pay particular attention to language and sounds. This is true, for example, with their mother's voice, which is familiar to them from their time in the uterus. It is not uncommon to observe the following phenomenon: a child starts to cry for some reason (such as hunger or discomfort), but they stop and listen attentively as soon as someone starts to speak to them or sing a song (even if they start crying again afterwards).

Very soon, they start to differentiate phonemes and diversify their own sounds themselves. All mothers are able to recognize their child's different cries. They cry in a particular way when they want to attract attention, and they cry in another way when they are hungry or need changing. These transformations occur in the first month or first two months.

At the end of the second month, the child starts to copy the background sounds around them as best they can: this is the babbling stage. This is not limited to speech, but concerns all the sounds they like. It can be the noise of a toy or an accessory, anything. Towards the end of the fourth month, the child starts to enjoy 'joining in' with conversations, especially if they are in an environment they know.

When spoken to, the baby will try to reply in its own way ("aaa", "brrrr"…). If the people around it are talking, it will try to participate in the conversation. It becomes highly receptive to all sounds, whether the noise of a car or a dog barking. Furthermore, the sounds uttered are nothing like the language being spoken by those around it. At this age, all the sounds emitted are linked solely to the physiology of the baby's vocal apparatus.

Production of the first syllables begins in the third trimester, between the sixth and eighth month. The child concentrates more and more on language. It already understands that this is the most effective way of getting everything it needs. In addition, it wants to be involved in its family's social life. In the sixth month, it tends to invert sounds: for example, instead of "mama", the baby will be more inclined to repeat "am am". From the eighth month onwards, all the letters resume their place.

At the end of the third trimester, the child adapts its babbling to the specific features of the language spoken by those around it. However, if it was immersed in another culture where a different language to the one it has heard thus far is spoken, it would only need a few weeks to find its marks once again, and this is true regardless of the language.

Thus, it will move easily from a Bantu dialect to Chinese or from Arabic to Greek. This is largely due to the fact that it is mainly satisfied with reproducing the sounds it hears. It is not so much about using the words accurately, but rather copying the rhythm and intonation. The more complex the word to be uttered is, the more tempted the child will be to only retain the intonation of the word, substituting or getting rid of all the complex letters.

Mum is a relatively easy word to pronounce, but all very young children will pronounce it as “mama”. Papa is a little more complex due to the consonant “p” and, in the vast majority of cases, babies start by saying “baba”. They also tend to accentuate the pronunciation of certain consonants. To return to the first word, “mum”, it is very often pronounced “mmamma”.

The fourth trimester can be considered as the actual start of the child’s initiation to language. The child is not only able to pronounce syllables or certain names; it starts to communicate actively with the people around it. It is able to pronounce several words with ease.

If the child is surrounded by lots of other children or if its parents encourage it to express itself, it will even form its first sentences. At this age, children are also prone to creating their own language. This phenomenon can be observed when several children of the same age socialize regularly. Until the end of the first year, the child is content to reproduce sounds as faithfully as possible. It only learns to recognize the phonemes typical to its language from the second year onwards.

From the age of one and a half, the child is already able to distinguish between its native language and a foreign language. It forms full sentences and, as far as possible, avoids substituting letters. It is not uncommon to read that children’s vocabulary at this age is made up of a maximum of five words, but this is not the case! In reality, once the child starts to pronounce its first word, the extent to which its vocabulary is enriched will largely depend on those around it.

It goes without saying that it is unreasonable to expect a one-year-old child to have as rich a vocabulary as a four-year-old or an adult. However, if babies are trained regularly from the ninth or tenth month onwards, their vocabulary will easily exceed 10 words by the time they are 18 months old. This period can also be referred to as the “no” phase. Indeed, this word can be found in most children’s vocabulary at this age, and they sometimes take huge enjoyment from answering “no” to almost everything.

To conclude this examination of the prelinguistic stage, we will look at how phonemes are learnt. Everyone knows that fetuses can recognize several sounds, including their mother’s voice, from the third trimester of life in the womb. However, their knowledge is not limited to sounds.

At this age, they are able to grasp phonemes (phonetic contrasts) that adults no longer perceive. From birth until the age of around 6 months, babies recognize phonemes in all languages easily. They then lose this ability and focus more on their native language.

The linguistic stage

The acquisition of one's native language is probably the most remarkable achievement that occurs in early childhood. For some, it begins between the ages of 12 and 16 months, because this is the age when babies finally develop dialogue skills. Although their vocabulary is limited, they are able to construct 'sentences' made up of two or even three words. In most cases, however, they only express themselves in single words.

Between 18 and 24 months, the vocabulary is already sufficiently rich and the child transitions from monosyllables and dissyllables (penultimate and final step in the prelinguistic stage) to a conversation that can already be described as sustained. At this point, it is impossible to determine how many words the child will have at its disposal.

From the end of the prelinguistic stage, the child's progress will depend on the stimulation it receives. If no delays or conditions are observed, the child will speak fluently: it will already have a stock of around 1000 words at the age of 3. It has often been hypothesized that, in the development of the human species, childhood was prolonged in order to adapt to the acquisition of a complex linguistic system.

In the processing of one's native language, it seems that the integration of semantic and pragmatic information follows the initial step of syntactic processing; this involves generating a syntactic structure that is bound by universal and language-specific requirements on the analysis of syntax, which are largely independent of semantic and pragmatic considerations.

Linguistic progress is also closely linked to the progression of individualization. Children become aware of their individuality and accept it. Between the ages of 2 and 3, the "no" phase continues. Admittedly, children are less categorical, but they try to assert their authority. They acquire the fundamentals of adult language at the age of 5 at the latest. The gradual transition from spoken to spoken and written language takes place during this period. Again, progress will be closely linked to the influence exerted by those around the child.

Development of written language

Unlike spoken language, which children can develop simply by listening to those around them, initiation to written language requires ongoing and sustained external support. What are the prerequisites for learning to read and write? Two conditions are involved: decoding and understanding information contained in the text.

Decoding

This rests on two pillars: alphabetic coding and automatism. The notion of alphabetic coding alludes to a perfect study of the alphabet of the language being learnt. If we only consider the child's development, this implies the visual perception and identification of each letter.

In almost all European languages, the alphabet contains between 22 and 30 letters. In Asian languages, the number is much higher; for example, Chinese contains a little over 3000 symbols. As such, the approaches to teaching in Europe and Asia cannot be the same. This is not only due to the number of letters, but also the complexity of the language. Logically, decoding 26 letters will be a faster process than doing the same for 3000 symbols.

Overall, the process remains similar and takes place in five phases: the preliterate stage, mastery of the alphabetic code, the logographic stage, the alphabetic stage and initiation to spelling strategies.

Preliterate stage – This first phase always begins with play: rhymes, drawings, etc. The aim of this approach is to increase phonemic awareness.

Mastery of the alphabetic code – During this phase, the child gradually learns to draw the letters or symbols that constitute the alphabet, but also to recognize how they are pronounced and specifics (vowels and consonants, in the case of the Latin alphabet). The child also learns how to use these letters and symbols to convey messages.

Logographic stage – The child is finally able to decode not only words, but also the terms they create. This marks the beginning of reading. The child gradually starts to decode words, then short sentences, long sentences and whole texts. At the end of this stage, reading simple texts and understanding them no longer poses any problems.

Alphabetic stage – The child now has a perfect mastery of the alphabetic code. The level of complexity of the texts it can understand is proportionately equal to the intensity of the training it receives. At this stage, the child does not yet have its own writing style, irrespective of its reading ability. Given the complementary nature of the processes of reading and writing, it is beneficial to encourage children to read as much as possible.

Initiation to spelling strategies – The child gets better and better at organizing words and is now able to put together complex propositions. The child has already acquired the alphabetic strategy, but it still relies heavily on the phonological procedure. For example, when a child hears the word “knee”, they will initially interpret it as “nee”. Context is required in order to arrive at the correct spelling, that is “knee”. During this stage, the child gradually learns to shift from a purely phonological interpretation to an orthographic representation. Adults take a primarily orthographic approach. This does not mean that phonological codes disappear with age; they are retained but simply intervene less and less in the processing of one’s native language. They are used once more when learning a new language.

Reading comprehension

Reading comprehension is exclusively linked to the sociocultural environment in which the child grows up. Decoding relies on the visual perception and identification of letters, and later words. It is a challenging learning process that involves external support; the child cannot succeed alone. The environment in which it lives can have an impact on the speed at which this process occurs, but it will be limited.

However, things change when it comes to interpreting this information. This relies on the subject’s mastery of the spoken language, experiential knowledge and general knowledge, hence the major influence of the environment. If a child grows up in an environment where it is constantly encouraged to read and learn, progress will be quick and comprehension will be excellent.

It is not uncommon to see children aged 9 or 10 reading texts that certain adults cannot understand, with a great deal of interest. If the environment in which the individual grows up does not encourage them to discover, and if they do not have a keen mind themselves, their level of comprehension will remain average, or in some cases very poor.

Different approaches

There has been a clear evolution in the areas of study for language, as is indeed the case for all areas linked to neuroscience. We have gone from a perception that was limited on a physiological level to a more extended vision of the origins and development of this process. Nowadays, there are four main branches.

✪ Purely linguistic analyses and studies

In these studies, researchers focus on sociocultural aspects: the genetics of languages and the history of the emergence of different groups of languages. Emphasis is placed on language in the sense of individual languages, and sometimes on language as a general phenomenon and means of communication, and not the people who use them. These studies disregard the physiological and anatomical aspect. Although these studies do eventually focus on people, this is only within the spectrum of the evolution of the language itself. Such studies include work on the evolution of dialects and languages through time.

✪ Primarily anatomical studies

These studies only consider the vocal apparatus and the ancillaries that produce language, but without overlooking the involvement of the central nervous system in its evolution. They seek to respond to questions such as: what are the interactions between their development and the evolution of language? And to what extent can a defect affecting the vocal apparatus influence the evolution of language?

✪ Studies on anatomy and physiology

In these studies, researchers analyze the entire configuration of language. They study both the anatomy of the vocal apparatus and the architecture of the brain and all the zones involved in the production of language. They focus on the cognitive impact.

✪ Studies focusing on the genetic and physiological aspect

Why are we able to converse while our ancestors were not? Researchers examine the functional architecture of the brain and the differences it exhibits compared to the brains of other primates.

Neuroscientists focus primarily on the last two categories.

Examples of theories

We will limit ourselves to examining those that are part of the areas of study of neuroscience. All these theories focus on the location of the areas of language, speech, imitation and linguistic cognition.

✪ Sydney Lamb's neurocognitive linguistics

Sydney Lamb's neurocognitive linguistics examines the language processing centers and describes "a system of cerebral functions relating to the mechanisms of speech (lower left zone), hearing (lower central zone), vision (lower right zone), vocabulary (central zone) and the categories of concrete and

abstract objects (central and upper right zone), which broadly correspond to the anatomy of the left hemisphere of the brain".

Despite having been supported when it was published, this theory is now considered simplistic, and for good reason: specialists now agree that Broca's and Wernicke's area are not the only ones to be involved in language processing. Neurocognitive linguistics limits itself to these two zones.

✪ Lieberman's theory on speech physiology

Based on studies conducted by Noam Chomsky and Steven Pinker, who described language as a capacity, the acquisition of which automatically requires learning, Philip Lieberman does not consider language as genetic information that is transmitted systematically.

He believes that aptitude for language is based on what he describes as the Functional Language System (FLS), which extends over several areas of the brain. This linguistic system is considered to be responsible for managing the production of language. Furthermore, he believes that this system underwent a long period of evolution, thanks to which it is now able to fulfil all these functions.

According to Philip Lieberman, although the foundations of this system are located on the neocortex, other elements of the nervous system also play an important role. These are the ganglions positioned on the subcortical base. He does not completely reject the role of genetics in language production, but he emphasizes one thing: this impact is minimal because the primitive structures that are responsible for managing language from a genetic point of view have just one aspect that is limited to regulating the process in its entirety.

Language and communication

The first theories relating to language and communication emerged at the beginning of the 20th century. At that time, these two terms were often considered synonyms, or at least to have similar meanings. Virtually all researchers and linguists started from the principle that all the signs and signals performed by humans are languages. Bertoni stated clearly: "Gestures are a language."

Although some of them, like Jespersen and Morris, recognized that there are methods of communication that cannot be described as language, they did not offer any scientific basis upon which to systematize these forms of communication.

It wasn't until around half a century later that the emphasis was placed on language. The very first theory on this theme described humans' ability to develop systems of communication that help them to rely on signifiers (perceptible phonemes) to describe the signified (non-perceptible phonemes).

Ultimately, language is therefore a communication system through which individuals transmit their opinions and ideas. Communication, on the other hand, is a broader notion that encompasses all forms of interactions between individuals. It is thanks to communication in general—and not language in particular—that we are able to socialize. This is why interest in studying the psychologies of language and communication is only increasing.

Linguistics: from general perception to the cognitive approach

Many linguistic theories have emerged since, and each one focuses on a particular aspect. Some concentrate on comparing languages by trying to analyze variations, but also typological approaches. Others seek to take an onomasiological approach, while the final category focuses on studying formal grammar. Despite how different they are, they all have one thing in common: they are all limited to the purely linguistic aspect.

The emergence of cognitive linguistics marked the appearance of another component: the cognitive aspect. Indeed, it would be impossible to address linguistic theories without considering the impact of neural and cerebral activity. Language, or rather the production of language, is not an automatic or automated process.

Humans can lose the capacity to express themselves without having suffered brain damage or injury. By considering the human mind as the essential element, we obtain a far more honest and 'naturalistic' view.

However, cognitive linguistics does not bring general linguistics into question. In the same vein, it does not allow itself to be sucked into neuroscience or psychology (this is particularly opposed to Chomsky's view, as he perceived linguistics as a subcategory of psychology).

It presents itself more as a complement to the classical vision, but also as an independent area of study. It is thanks to cognitive linguistics that we have seen the emergence of sciences like neurolinguistics and psycholinguistics.

The key concern of cognitive linguistics is the representation of the conceptual structure in language. Thus, it addresses the linguistic structuring of fundamental conceptual categories like space and time, scenes and events, entities and processes, movement and location, and force and causality.

In addition, it addresses fundamental types of cognition, such as attention and perspective, intention and affect. Thus, it tackles the interrelationships between conceptual structures, such as those of metaphorical mapping, those in a semantic framework, those between a text and its context, and those of the combination of conceptual categories.

The psychology of language

The evolution of the perception of processes linked to language and communication that took place in the mid-20th century pushed researchers to dwell on the study of the psychology of language. The psychology of language is defined as "the study of the cognitive processes implemented in the processing and production of language".

It studies the processes involved in language acquisition and comprehension, as well as those involved in discursive production. The first two principles are described later in this module, but the final one deserves particular attention.

Discursive production is characterized as the analysis of the mechanisms required for language production (a mental and physical process). Here, it is important to put things in perspective. There is a clear difference between the processes of language and speech production:

- Language is not necessarily spoken. It can be written or be done through signs and, in this case, will differ from speech.
- The production of speech takes place through the vocal apparatus and the neural connections. Furthermore, it can be spontaneous and sometimes uncontrolled. This is the case when an individual talks in their sleep, exclaims or pronounces a written word robotically.

Theoretically speaking, we utter around four syllables a second during a conversation. We also mispronounce at least one word in every 900 words. Of course, we find it much easier to pronounce familiar words and expressions than those we rarely use. Speech production is sometimes also accompanied by gestures. This is with a view to improving perception.

As this course is on cognitive neuroscience, it seems logical to focus on psycholinguistics, because it concentrates on the cognitive aspect. Psycholinguistics is based on the following pillars:

- **Language skills,** which are divided into two categories:
  - primary abilities, which encompass the capacity to learn, understand and, of course, express oneself in a concrete language;
  - secondary abilities, which describe the capacity to think in the language being spoken and store information provided in this language.
- **Levels of linguistic analysis**, which describe the different steps in linguistic processing. All these levels are complementary, which means that if one fails, the entire system fails. There are seven of them:
  - the acoustic-phonetic level, which relates to phonemes, sounds, tone: the acoustic aspect of language;
  - the phonological level, which analyses the functions of these sounds;
  - the morphological level, which looks at the changes in form of words in an expression;
  - the lexical level, which primarily analyses vocabulary;
  - the syntactic level, which deals with grammar;
  - the semantic level, which focuses on the meaning of each sentence uttered;
  - the discursive level, which focuses on the meaning of an entire text.
- **Targets**, or in this case the target population. They are usually divided into three categories: aphasic individuals, bilingual (and multilingual) individuals, and those who only speak and understand one language. Age does not matter because these three categories are found in all age brackets once they have come out of the pre-linguistic phase.
- **Mode**, which describes the medium. This includes audio support, visual support, gestures (language with gestural support used by individuals who are deaf) and tactile support (individuals who are blind rely on this medium).

- **Context**, which refers to a linguistic context. It is the method used when observation and experience interact.
- **The target languages** or those the individual is studying. There is no need to demonstrate that every language has its own specific features (here, we focus on morphological structures), but that all languages also have things in common.

Analyzing and understanding all the elements above helps us to grasp not only the specifics of language, but also the psychology of those who use it. Each of these six phases represents an area of study that is relatively vast in itself. As an example, we'll look at the primary abilities within language skills: perception, comprehension and production of language.

Word comprehension

This is dependent on:

- decoding the sounds that make up words;
- distinguishing each word;
- understanding each word.

Understanding each word begins by understanding the sounds of which it is made up. The phonemes in every word are specific to it. If we were to change their position, the word would lose its meaning and would no longer be recognizable as a result. This is a phenomenon we observe regularly in languages that are part of the same family. As an example, let's take two Latin languages: Spanish and French.

In Spanish and French, the majority of the alphabet is the same. In French, however, /r/ is not a phoneme (whether you pronounce the word "mer", meaning sea, with a rolled /r/ or not, the word retains the same meaning); in Spanish, /r/ is a phoneme (the word "pero", meaning but, changes meaning if the /r/ is rolled more to produce "perro", meaning dog); this difference can be seen in writing, but what matters is what happens in speech.

Distinguishing the word is followed by perception of the word. This does not mean that we always hear the word in its entirety. We observe two phenomena during this phase: phonemic restoration and discourse segmentation.

✪ Phonemic restoration

Let's take a simple example. One person says to another from a distance: "Keep an eye on him, I think he's ex…", then coughs, then "sted". Anyone you ask to guess what this person might have said has no chance of getting it wrong. In the same vein, it is highly unlikely that the person being spoken to will ask the speaker to repeat themselves. Even though the sentence was not uttered in full, we can imagine that the individual meant to say: "Keep an eye on him, I think he's exhausted."

The individual decodes the sentence, despite the missing letter or sound, using this knowledge but also the meaning and context of the sentence. For example, if the individual hears "after the baby", they will be forced to ask their interlocutor to repeat themselves, because this could have many different interpretations: "look after the baby", "… after the baby has been fed", etc. On the other

hand, if they hear "… after the baby and cradle him because he's tired", they will fill in the missing part of the sentence without any difficulty.

Understanding fluent speech in one's native language requires listeners to integrate the detailed acoustic and phonetic information available in the sound signals with linguistic knowledge. This interaction is particularly visible in phonemic restoration, a phenomenon whereby a missing phoneme is "restored" through the influence of information coming from vocabulary and through bottom-up acoustic processing.

✪ Discourse segmentation

Discourse segmentation is a method of selection through which the individual filters information in order to assimilate it as quickly as possible, regardless of the circumstances they are in. This is important when required to listen to a stream of words, especially when it is not broken up by pauses. This phenomenon can only be observed if the individual analyzing the discourse possesses a certain amount of knowledge of the language they are analyzing.

The phenomenon of phonemic restoration requires analyzing the context of the sentence that is uttered. In the present case, the individual will focus more on intonation. In every language, there is a set of extremely commonly used words. By dint of listening to them, the individual learns to recognize their intonations and, as a result, there is no longer any need for them to finish pronouncing the word or words. The brain will automatically fill the gap as long as it hears a phonation similar to that with which it is familiar.

A study was conducted on this phenomenon. The subjects waited in a room and, without their knowledge, were recorded while they spoke amongst themselves. During the experiment itself, they heard one isolated word from their own stream of words. Although these words came from themselves, they were unable to identify half of the words presented. The conclusion drawn was that half of the words we utter are unintelligible when taken out of context.

The factors that complicate discourse segmentation include poor knowledge of the language and a strong accent on the speaker's part. Overall, word comprehension is heavily influenced by several factors, including the word frequency, the context of each sentence, the word complexity and semantic priming.

Sentence comprehension

Sentence comprehension refers to the cognitive processes that the speakers of a language have to carry out to distil and understand the meaning of utterances as they are spoken in real time. This is the logical continuation of word comprehension. Once the individual manages to decode each word, they grasp the meaning of the sentence.

Each area of the brain is responsible for managing certain actions. Syntactic and semantic processing do not take place in the same area. Furthermore, just one word can modify the processing area for a whole sentence.

However, the analysis and decoding of the different elements of the sentence do not happen independently. These processes are complementary and are only effective when they take place at

the same time. As a reminder, semantics analyses the meaning of sentences, while syntax deals with assembling the appropriate words and phrases to form an utterance.

The processes of analysis involved in decoding sentences are not dissimilar to those for words. Just like in the previous case, sentences are parsed based on their syntactic and semantic complexity, and the speed of information processing will be closely linked to the individual's command of the language.

There are two forms of parsing: interactionist parsing and syntax-related parsing. Syntax-related parsing only considers the syntactic aspect, whereas interactionist parsing relies on both syntax and semantics. The elements that help to interpret sentences correctly include:

- coherence, which involves harmonizing the different parts of the sentence or text;
- inference, which is derived from coherence and describes "the process whereby the reader, while reading, creates information that is not given explicitly in the text";
- anaphoric inference, which connects the people and articles mentioned in a sentence with the same people and articles described in another sentence;
- instrumental inference, which is similar to anaphoric inference but connects methods;
- causal inference, which draws on the same principle but with events.

Once the individual understands the meaning of the full message being transmitted to them, they have the option to be content with receiving this information and keep quiet, or transmit their own message as a response to the one they received. This leads into the following phase: speech production.

Speech production

This is how humans generate meaningful speech. It is a complex feedback process that involves hearing, perceiving and processing information in the nervous system.

Speaking is essentially the by-product of an essential bodily process: the expulsion of air charged with carbon dioxide from the lungs after it has fulfilled its role in respiration. Most of the time, we exhale silently. However, it is possible to modify the characteristics of the air expelled from the lungs by contracting and relaxing the vocal tract.

Speech production takes place in three stages: conceptualization, formulation and articulation.

✪ Conceptualization

This is the stage during which the individual develops the idea to be expressed based on the context. This process is described as 'competitive' because it is a highly selective phase, as the subject has to choose one or several words from a huge mass of options.

✪ Formulation

Once the appropriate words have been selected, then comes the expression phase. This process also includes others, for example creating a syntactic framework and phonological encoding, which

determines the phonetic form of the planned utterance. During this stage, an abstract conceptual form is selected: that of a word devoid of information on the sounds that make it up.

✪ Articulation

This is the final phase, during which the subject utters the word or sentence formed. This step involves not only the expression of the words selected, but also strict adherence to the intonation of each word. In some languages, incorrect phonation can lead to severe misinterpretation. This phase is purely anatomical. The accuracy of pronunciation is reliant on perfect coordination between all the elements of the vocal apparatus.

The cognitive psychology of language, like all self-respecting sciences, is constantly evolving. Nowadays, the most popular areas of study are language development and production. The diverse range of areas of study offers a better understanding of all these processes.

The psychology of communication

Generally, communication encompasses all the elements that exist when individuals interact. Thus, it involves all the forms of language and interactions that result in the transfer or receipt of information.

Thus, the psychology of communication covers several areas, including social psychology. Indeed, studying all the aspects of communication also involves taking into consideration the personality of each individual who participates in this exchange.

Before taking a detailed look at all the communication models, we will give a brief overview below.

An emitter, X, transmits information to a receiver, Y. Transmission can occur in one direction only, or receive a response. In the latter case, this 'feedback' creates a feedback loop that determines the relationships between the individuals who are interacting. Feedback is useful for both the emitter of the initial message and the recipient ('feedback emitter'): it makes it possible to make sure the original message has been understood correctly; in the event of error, the initial emitter can correct or clarify their idea.

For the 'feedback emitter' recipient, it is also a way of making sure they are on the same wavelength as the emitter of the initial thought. This interaction is important in all aspects of life. Let's take the conversation between a patient and their doctor as an example. In the medical sphere, communication is the cornerstone of relations with a patient.

Indeed, it is essential in order to create a positive interpersonal connection, exchange information and make the right decisions relating to treatment. Effective communication is fundamental to guarantee good care. The success of treatment will largely depend on having a good understanding of the information transmitted between the two participants in the conversation.

Communication is a bidirectional interaction where information, meanings and feelings are shared. Effective communication transmits the correct information; allows others to understand the feelings and meanings an individual is seeking to convey, and express a caring attitude; and, to a certain degree, helps to avoid interpersonal conflicts and reduce misunderstandings.

However, communication goes beyond simply transmitting ideas or information. Understanding the different principles will depend not only on the context in which it takes place, but also the relationships between the speakers. This is why the psychology of communication encompasses several branches of psychology (psychology of language, social psychology, etc.).

Communication is studied by cognitive and experimental psychologists, and communication disorders are treated by mental health and behavioral therapists and by speech therapists.

There are several forms of communication and a specific approach needs to be taken to each of them. Overall, there are four communication models: oral communication, visual communication, gestural communication and written communication.

This classification can also take the nature of the conversation into consideration. This can include professional communication, informal communication and commercial communication.

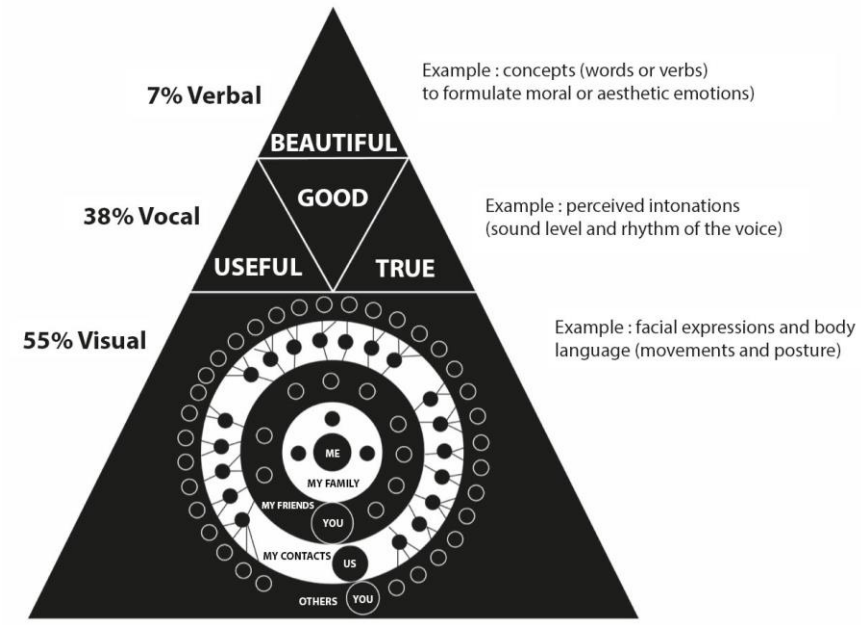
The final significant factor is the number of people who are involved in the communication. Thus, we distinguish between interpersonal communication and group communication.

Communication models

✪ Oral communication

What comes to mind first when referring to oral communication is the means of expression: verbal. However, although this might seem obvious, it is not. Studies conducted by Albert Mehrabian tend to indicate that just 7% of oral communication is actually verbal.

This psychology professor realized that, during any oral conversation, we pay more attention to the intonation, facial expressions and gestures used by the person to whom we are speaking than to the meaning of their words. Drawing on these observations, he developed a rule that quickly became very popular: the 3 Vs.



The principle of this law is simple. In reality, oral conversation is founded on three basic principles:

- The verbal aspect itself: this relates to the pronunciation of words and decoding of their meaning.
- The vocal aspect: the individual pays attention to the intonation, the volume of the voice, and even the pauses the speaker makes during the conversation.
- The visual aspect: the individual focuses on their interlocutor's body language in detail. Very often, the way a person behaves during a conversation says more than their actual speech. Specialists can determine whether the individual is stressed, relaxed, open, lying, etc.

There is no doubt that during an oral conversation, each interlocutor pays attention to more aspects than the words pronounced. However, it would be incorrect to limit this communication to simple decoding of signs and gestures. Unfortunately, many people who use this technique make this very error.

It is important to pay attention to certain particularities. This rule is only effective when the speaker tells their interlocutor about their emotions or is under the influence of their emotions. Let's look at some examples of this.

- **Example 1**

During a discussion, Mr. X tells Mr. Y about the feelings he has for the latter's daughter. After a few minutes, Mr. Y trusts Mr. X less than he did at the start of the conversation. It seems to him that his interlocutor's intentions are far from honest.

- **Example 2**

Mr. A has just been arrested. He is suspected of having committed a crime. The detective charged with conducting the investigation questions the suspect and asks him concrete questions. Given that he does not expect his interlocutor to be open and sincere, he will also focus on his paraverbal language. How does Mr. A react to the questions he is asked? How does he respond? Is he stressed, tense or more relaxed?

- **Example 3**

Mr. D is a businessman and Mr. E is an investor. The former explains to the latter why he would benefit from trusting him and making a financial investment in the business he is in the process of starting up. At the end of the presentation, Mr. E, who had initially been enthusiastic, starts to have doubts.

At the end of the conversation, Mr. E no longer wants to participate in Mr. D's project. However, the other investors who are present, and less experienced than him, are all convinced by Mr. D's words. Mr. E probably should be too, but there is something about Mr. D's behavior that makes him suspicious.

- **Example 4**

Mr. H and Mr. J are discussing the notion of happiness seen from the perspective of different philosophers. Mr. H's vision is that of Epicure, while Mr. J's is much closer to John Stuart Mill's perception. Mr. J is determined to convince Mr. H, but fails. None of his arguments manage to persuade the latter to adopt the same position as him. Mr. H tries to do the same with Mr. J, but also fails.

Mehrabian's rule stipulates that 7% of oral communication is verbal. This means that 93% is exclusively paraverbal. Let's now see whether this rule is applicable in the four preceding examples.

For the first three examples, the answer is yes. Mr. X, Mr. A and Mr. D are not simply having a discussion with their interlocutors; they are emotionally engaged. Now, expressing emotions is always linked to unregulated gestures and expressions. Few people are able to control these unconscious behaviors. This is why Mr. Y, the detective and Mr. F benefit from focusing on their interlocutors' paraverbal language, as it will offer them far more information than their verbal communication.

However, even in this case, it is impossible to affirm that 93% of the conversation between the different interlocutors will be paraverbal. The physical reaction is partly linked to the individual's personality. Some people are less emotionally expressive and, as a result, they will be less inclined to let their emotions show, even unconsciously.

In the fourth example, the situation is totally different. There is no doubt that Mr. J and Mr. H are emotionally engaged in their conversation, but only because both of them think they can convince the other. In this case, it is simply a passionate exchange of information.

People's systematic interpretation of this rule — namely believing that oral communication is always made up of 7% verbal conversation and 93% paraverbal conversation — caused Albert Mehrabian himself to lament. He believed that those who apply the rule did not take another decisive factor into consideration: the psychological aspect.

✪ Visual communication

Visual communication, also known as graphic communication, is described as "the formulation of shapes and graphic elements (images, font, photos, colors, etc.) with a view to communicating information to a designated audience".

Visual communication is mainly cultural. It might seem universal, but this is not the case. Let's look at an example.

To launch a clothing line, a marketing specialist focuses on a range of white garments. They present them as a symbol of purity and lightness. This is an American specialist who is launching a clothing line in India.

One of their colleagues, who is Indian, is given the exact same task, but for another brand. They decide to focus on red garments and present them as the symbol of happiness and joy. They live in Saudi Arabia.

As surprising as it might seem, both of them experience a resounding failure.

For clothing, white is the quintessential color of purity and happiness. Is it strange that Indians were not convinced by this? Not entirely! The American specialist had no chance of success with their campaign from the start. In India, white is primarily associated with mourning. It was therefore highly unlikely that the target market would have the desired reaction.

The same is true for the Indian specialist. The color red is associated with happiness and marriage in many Asian countries. In the West, it is the color of sensuality. However, in the Middle East, this color is considered too garish.

In both cases, the visual message transmitted by the specialists did not align with the cultural particularities of the regions in which they were located. What is valid for colors is also valid for shapes, images, videos, and even fonts.

✪ Gestural communication

This form of communication has many things in common with visual communication. They are both linked to the subject's culture and education. However, there is a difference between these two forms of communication. Some gestures are universal, and in many cases, there is no need to learn them. Let's take an example to illustrate this.

Liam is a 19-year-old student from Nigeria. He has been living in Russia for two months and is struggling to understand the language. He usually does his shopping with another student who is Algerian. The latter also has a minimal grasp of the language, but it is superior to Liam's because he has been living in Russia for almost 2 years now. Today, Liam has to do the shopping on his own because his friend is ill.

To avoid getting into an awkward situation, he goes to a market where he will have virtually no need to speak. He will be able to get what he needs at his leisure and pay without any problems. However, there's a problem: he can't find the eggs. The market is quite large and Liam is worried about getting lost. How can he find the eggs he needs if he is not capable of communicating normally?

After thinking for a few minutes, Liam spots a woman nearby who is selling poultry. He smiles, walks towards her, points to a chicken and, before she has time to answer, pretends to cradle a baby. He then asks her just one question: where is it? The stallholder and everyone around burst out laughing, but the young student has achieved his goal. One of the sellers decides to act as a guide and shows him where he can buy his eggs.

Would the student have achieved the same result in another country? The answer is, without doubt, yes. In any corner of the globe, at least one person would have understood that he was looking for eggs. This is far from being an isolated example. Someone who is crying, regardless of their age, is perceived as being in distress. Gestures that indicate basic functions like drinking, eating or sleeping are also universal. Overall, gestural communication is made up of both elements that are universal and elements that are deeply specific and cultural.

✪ Written communication

This form of communication is only possible after a long period of learning. It is also the most complex and least emotional form of communication. Oral communication, regardless of the domain, inevitably involves a certain projection of the interlocutor's feelings. The listener is able to sense happiness, irritation, authority, sadness and anxiety in the voice of the person speaking.

In written communication, we find nothing of the sort. Whatever the emotions expressed by the interlocutor in writing, it is impossible to get an idea of the true intentions of the person who wrote the message. Written communication also has the distinction of being subject to several different interpretations. Let's take the example of a relatively simple exercise.

The instruction is as follows: "Place the six balls that are currently next to you on the mat you see on the hill opposite you."

What should you do? Many people who read this instruction will take the balls and go and place them on the mat. However, some will simply go and get the mat in question and place all the balls on it to avoid going back and forth needlessly.

The instruction says to place the balls on the mat that is on the hill, but there is nothing to suggest that the balls must also be placed on this hill.

Another particularity of written communication is that it is generally always delayed. The emitter writes a message that is to be transmitted to the recipient. If the latter does not understand the document sent, they will have to ask the emitter for clarification. To avoid any misunderstandings, the words chosen and the style adopted will need to be precise and concise.

Precision with regard to words used is an obligation that also needs to adapt to the writing style of the message being transmitted. With written communication, the emitter is bound by a certain degree of rigor and discipline because the recipient is dependent on them. This position makes it even more demanding. Indeed, to avoid any criticism from the recipient, the emitter is required to analyze each word and make sure it expresses the idea they wish to transmit perfectly.

Last but not least, this form of communication requires interlocutors to have a perfect mastery of the language in which they are communicating. For the emitter, this means systematically following all the rules relating to vocabulary and grammar. The recipient, meanwhile, needs to have a concrete idea of all the phrases and expressions in the language in order to grasp the subtleties of the message being transmitted to them. In certain domains (academic, professional, legal, etc.), the writing constraints are even stricter.

The success of written communication rests, with a few exceptions, on the WWWWWH (Who? What? Where? Why? When? How?) rule. Every idea conveyed in the message must exclusively answer these questions. Any supplementary information is superfluous and therefore useless.

Nature of the conversation

Regardless of the conversational model adopted, its complexity rests primarily on its nature. Professional communication demands strict compliance with all the communicational rules that exist.

Professional ethics are key, as well as grammar and vocabulary rules. Note, however, that this is far from being universal. Professional communication in Asia will be completely different to how it is in the Middle East or the West. The same is true for informal and commercial communications.

Nevertheless, it is important to bear in mind that the impact of the cultural aspect is itself linked to the nature of the conversation. It is less pronounced in commercial or professional communication because the process is generally universal. Very often, communication takes place between people from different backgrounds, but there is a common foundation that is accepted virtually everywhere in the world.

Informal communication, meanwhile, is much more personal. As a result, the cultural influence is heightened.

Influence of the number of speakers

The way any conversation unfolds is closely linked to the number of people participating in it. There are two situations: interpersonal communication and group communication.

✪ Group communication

As its name suggests, this involves several interlocutors. We generally distinguish between two forms of group communication:

- mass communication;
- actual group communication.

Mass communication involves a virtual absence of interaction. Generally, there is an emitter or a small group of emitters transmitting messages to a large number of recipients. It is not uncommon for mass communication to take on a manipulative character. In line with this, it is also common for the initial message to end up getting lost. Mass communication only has one advantage: it is rapid.

Group communication has some things in common with the first type of communication, but it is more 'individual'. During a mass communication, dominant forces impose their opinion on a group of 'dominated' individuals. The opinion of the latter is generally irrelevant, so the emitters do not expect any interaction.

The situation is totally different during group communication. Often, active involvement is required from each member of the group. However, if one of the group members has some form of authority, the rest of the interlocutors, or rather recipients, will be restricted by a feeling of inferiority. This can restrict the amount of feedback from the potential recipients as a result.

✪ Interpersonal communication

This can be intimate or more formal, but it has the benefit of being direct. The characteristics of the interpersonal communication will depend on the means of communication. It will take on all the characteristics of oral communication if the interlocutors are interacting directly. If the communication is taking place remotely, it will have more of the characteristics of written communication.

Is language specific to humans?

Language is a means of communication, but also a set of specific signs. All living beings communicate with each other. Plants do this through colors and animals do it through sounds and movements. Thus, to answer this question, it is necessary to first determine the meaning attributed to the notion of language.

✪ Language as a form of communication

If we consider language as a form of communication that enables individuals to transmit a message to each other, we have to recognize that it is not specific to humans. The problem is that this perception immediately gives rise to other questions, one of which is whether we can consider the meowing of cats as equal to human language.

The answer will be yes if we perceive language as a means of transmitting simple messages. However, if language needs to transmit complex ideas and profound thoughts, the answer will be no. Cats can express a sexual instinct, but only humans can describe in detail the emotions they feel. This therefore leads to a different vision of language.

✪ Language as a system of signs for complex communication

If we see language as a specific system of signs that is double-articulated and that serves to communicate, and also as the ability to produce and use a language, it would be tempting to draw one conclusion: language is unique to humans. However, several studies conducted on higher primates have proven that, with a little practice, they are able to assimilate sign language.

However, language has an informative power and it must above all help individuals to express what they think, in all its ambiguity. Gaining command of a language is an evolving process. This means that eventually, the subject needs to be able to express a plethora of thoughts and feelings using this means of communication alone.

Primates are not able to do this. First, they will only be able to master a limited number of signs. Second, they will limit themselves to using the 'words' (gestures) they are accustomed to using and make do with repeating those that enable them to satisfy their needs. Ambiguity, irregularities, redundancy, asymmetry, double articulation and many other elements common to all languages used around the world, will remain inaccessible to primates. We can therefore conclude that language, as a complex form of communication, is specific to humans.

Language disorders

Language disorders inhibit children's ability to understand the code, reproduce the code, or both. They include:

- Expressive language disorders: these involve difficulties formulating ideas and messages using language.
- Receptive language disorders: these are difficulties understanding the messages encoded in language.
- Receptive expressive language disorders: these are difficulties both understanding and producing messages encoded in language.

Language disorders can also be classified based on whether they have an impact on pragmatics, semantics or grammar. Pragmatic language disorders can be observed in children who generally lack social reciprocity (dynamic exchanges that characterize the first communicative interactions).

A child who suffers from a receptive pragmatic language disorder may have difficulties understanding messages that involve abstract ideas like idioms, metaphors and irony. A child who has an expressive pragmatic disorder may struggle to produce messages that are socially appropriate for a given audience or context.

A child with a receptive semantic disorder may not understand as many vocabulary words as is expected of a child of their age. A child with an expressive semantic disorder may struggle to come up with the right word to express their intended meaning precisely. A child with a receptive

grammatical disorder may be unable to understand the differences between word endings that indicate concepts.

It is essential to determine the underlying etiology of a speech or language disorder in order to be able to offer the child a set of suitable interventions and help their parents to understand the cause and natural history of their child's disorder. There are many different causes of language disorders. They can result from physiological or psychological issues, and the environment in which the child grows up also plays a significant role.

✪ Physiological and genetic causes

Statistics show that boys are more affected by language disorders than girls (three to five times more). Furthermore, if a family member has suffered from a language disorder (or is currently suffering from one), it is highly likely that a child in the family may also be affected. If two members of the same family are already affected, there is three times the risk of the phenomenon repeating itself.

Various congenital and acquired conditions can lead to abnormal development of speech and/or language. These conditions include primary auditory disorders, specific genetic conditions, cerebral malformation syndromes, inborn errors of metabolism, toxic exposure, nutritional deficiencies, injuries and epilepsy.

The physiological causes of language disorders are still poorly studied. The example of dyslexia proves this. There is a vast range of theories regarding the origins of this disorder. These include the phonological theory, the rapid auditory processing theory, the auditory theory, magnocellular theories (visual and general) and the cerebellar theory.

✪ Psychological causes

One of the main causes is stress, whether that experienced by the mother prior to giving birth or by the child after birth. Prenatal stress very often has an impact on the baby's cognitive development. One of the consequences of this is pronounced learning difficulties, and therefore learning delay.

Postnatal stress or simply stress experienced by the individual can also cause language disorders. It is important to know that these disorders can affect both children and adults. In the latter, this is often a consequence of memory problems.

✪ Environmental causes

In this category, we will group parents' behavior towards the child, the environment in which the child grows up, physical accidents, conditions, etc. These factors affect both children and adults. A child who suffers violence at the hands of their parents from an early age is highly likely to develop language disorders. The same is true for a child to whom no one speaks.

The quality of the language in the child's environment can also have an impact on whether disorders manifest themselves. This is one of the reasons why it is advisable to speak to babies normally rather than using "goo-goo ga-ga"-type language.

The different language disorders

The specific language disorder is a developmental disorder that affects a range of different linguistic profiles in the context of normal development in other domains (although this is increasingly debated). A developmental language disorder is characterized by the inability to master expression and comprehension of written and spoken language despite possessing nonverbal intelligence, normal hearing and motor speech skills, and no noticeable physical impairment, recognized syndrome or other mitigating medical factors known to cause language disorders in children.

We distinguish between two broad categories: written language disorders and oral language disorders.

✪ Written language disorders

These include dyslexia, dysorthography, dyscalculia and dysgraphia.

Symptoms of dyslexia

Dyslexia is characterized by:

- omission, substitution and inversion of sounds in words (bet for bent, rut for rust, etc.);
- confusion between mirrored letters (b/d, p/q) and sounds that are close to each other (ch/j, d/t);
- significant difficulties with decoding (slow, non-fluent reading);
- difficulties recognizing words in general;
- difficulties reading irregular words (weight, debt, father, earth, etc.);
- tendency to skip small linking words in sentences;
- difficulties understanding what they are reading because the child is focused on decoding;
- severe fatigue during reading-based tasks.

The child will sometimes guess words by relying on the first letters or the meaning of the sentence, which can delay diagnosis.

Symptoms of dysgraphia

This disorder has many things in common with dyslexia. In fact, the majority of people with dyslexia also suffer from dysgraphia. The most common symptoms include:

- difficulties with writing (this encompasses both problems with writing, and difficulty completing any activities involving writing in general);
- the presence of irregular spacing between syllables, letters and words.

Symptoms of dysorthography

Unlike the preceding condition, this is not always linked to dyslexia. It manifests itself as an inability to remember rules relating to syntax, spelling and/or grammar.

Symptoms of dyscalculia

Dyscalculia is characterized by multiple difficulties in the following areas:

- counting (with the fingers or other objects often being used to count);
- reading and writing numbers (reading 26 for 62, writing 707 for 77, reading 6 for 9, etc.);
- performing arithmetic operations;
- remembering times tables;
- grasping and using mathematical terms (difference, sum, quantity, more than, less than, twice as many as, etc.);
- understanding statements of mathematical problems;
- dealing with money.

It can be diagnosed through poor visuospatial orientation (difficulties orientating oneself in space) and problems with geometry.

Oral language disorders

These include aphasia, stuttering, articulation disorders and dysphasia.

Stuttering

This is one of the most widespread conditions. It generally appears around the age of 3, or at the age of 7 at the most, and can be temporary or permanent. The origins of stuttering are still unknown, but some studies show that it can be due to a psychological or genetic cause. The more quickly the condition is managed, the more likely the individual is to be able to overcome it.

Aphasia

Aphasia (of which there are several types) is the result of brain damage. Like stuttering, it is not accompanied by the degradation of other cognitive activities. However, there is no form of treatment available; it is simply about finding ways of reducing the negative effects slightly.

Articulation disorders

These concern incorrect pronunciation of certain letters (s, r, etc.). This disorder is relatively common, but unlike all the other language disorders, it is easy to treat.

Dysphasia

This disorder manifests itself in two ways: receptive and expressive. The most common symptoms in children are:

- On a receptive level (comprehension of language):
  - limited comprehension of vocabulary;
  - difficulty understanding abstract words;
  - inability to understand or differentiate question words (for example where, when, how, why);
  - difficulty understanding long and complex statements;

- literal understanding of messages (without nuance).

These indications can often make it seem like the child is inattentive.

- On an expressive level (expression of language):
  - often inadequate use and organization of sounds within words;
  - difficulties finding the right word;
  - overuse of 'passe-partout', generic words (such as thing, stuff);
  - atypical sentence construction (for example using the verb before the subject);
  - hesitations/pauses when speaking;
  - difficulties defining ideas or concepts verbally;
  - misuse or omission of linking words.

Most patients who suffer from language disorders have more than one primary language disorder. They often experience problems that are also due to other cognitive disorders (such as attention deficits or problems retrieving information from the semantic memory).

However, people affected by language processing disorders adapt to their condition in several ways; some of these adaptations are remarkably effective to maintain at least some aspects of functional communication. Time, retraining, support and a positive attitude can make it possible for many patients to take a productive approach.

Development of and treatments for language disorders

If diagnosis and treatment are performed quickly, it is easy to overcome the majority of language disorders. It goes without saying that some of them, like aphasia or disorders that originate from other conditions like autism and alalia, are difficult to overcome. Nevertheless, it is possible to reduce the negative effects and improve the patient's state at least partially.

Treatment depends on the condition. However, one element forms part of all treatments, regardless of the origin of the disorder. This element is music. Music and language are processed in the same way by the brain. They both depend on elements organized into hierarchical structures: for language, these are phonemes and words, and for music, they are notes and chords.

These structures can be described using 'syntax'. As a result, the processing of linguistic structures, just like that of musical structures, requires memory, attention and a capacity for temporal integration of events in order to create a coherent mental representation.

One of the advantages of music is its aesthetic quality. Speech therapy is a process that is slow, long and often very difficult for patients. The older the patient is, the less well they will respond to conventional treatment, because they will end up developing an inferiority complex that prevents them from moving forward or slows progression. Using music makes treatment more pleasant. The

patient performs the same actions as during conventional treatment, but no longer feels oppressed by the environment.

As an example, consider singing for people who suffer from a stutter. The possibility of singing freely reduces the psychological pressure. Practicing music leads to a distinct improvement in language, but is never perceived as a form of treatment by patients, which increases its positive impact.

Techniques for improving language and communication

In Western countries, the majority of the population only speak one language. In Africa, South America and Asia, it is relatively common for people to speak two or several languages.

A huge percentage of Africans are multilingual. They express themselves with ease not only in their native dialect, but also in two, three or even four other dialects, some of which may not fall within the official language.

Why is the situation different in the West, and how can individuals master several languages?

✪ Being multilingual from birth

Language activates two areas: Broca's area and Wernicke's area. The latter is involved in language comprehension, while the first is involved in oral expression. The way they function is completely different: Broca's area reacts in a far more specific and localized way than Wernicke's area.

However, if the individual grows up in a bilingual or multilingual environment from birth, their Broca's area starts to behave like Wernicke's area. It no longer differentiates languages that are learnt at the same time. This offers a significant advantage that can then be exploited by individuals who wish to learn an additional language.

This is why it is important to introduce children to language learning at the earliest age possible. However, learning must be structured so the child can distinguish between the different languages. Indeed, as Broca's area no longer distinguishes between languages, the child may be tempted to speak using a mixture of all the languages they have learnt.

✪ How can a language be learnt quickly?

There is only one effective way to achieve this: by practicing continuously. The conventional way of studying languages is completely inefficient, neurologically speaking. Reading texts, studying grammatical rules and learning pronunciation have their advantages: they help individuals to familiarize themselves with the language. However, everyone who has done this can testify to the fact that, even after several years, they were unable to communicate normally with someone who speaks the language in question.

This takes us back to the initial observation made regarding Western populations and Asian or African populations. The latter start to communicate with members of other ethnic groups and tribes, sometimes from a very early age. After a few months, they are able to not only understand, but also express themselves freely in their neighboring dialects. All scientific studies that have been carried out to this day confirm these observations.

The following elements are crucial to learning one or several languages:

- The individual must use the language constantly, or at least as often as possible.
- The individual must use the language for specific purposes. It is not about speaking simply for the pleasure of pronouncing words; it is about choosing a concrete aim, for example knowing how to ask for help in Germany or how to find your way in Russia. Setting a specific goal prevents the brain from spreading itself too thin on trivial things.
- If the individual does not live in the country where this language is used, they must employ authentic linguistic material. These include audio and/or video extracts of conversations and real exchanges in the language.
- The individual must converse as much as possible with people for whom the target language is their mother tongue.

Failing to adhere to these principles will only slow the learning process, regardless of the amount of effort invested.

Conclusion

Communication is a cognitive function that we rely on from the very first days we are alive. By crying, babies do not only express their discomfort, but they also display a certain desire to communicate. It always attracts the attention of their mother or those around, to them and their condition. Gradually, babies acquire the ability to transmit and also receive messages. In short, they develop the ability to communicate.

The acquisition and development of language in particular and communication in general are not just physiological processes. Having the ability to express oneself and understand one's interlocutor also plays an important role in the individual's psychological growth. This is the first phase of socialization, and the example of 'Mowgli children' demonstrates this.

It is impossible to imagine how an individual could experience socialization without being able to communicate. Here, we are focusing not on language itself, but actually on communication. Mastering language involves mastering one or several concrete languages. Communication, meanwhile, is based more on the individual's ability to transmit messages, regardless of the language as a tool and language as an ability to communicate used to achieve this.

It is not surprising that neuroscience focuses on language as an ability to communicate, and all the inherent processes involved. Its impact on the individual's cognitive abilities is immeasurable, and therefore cannot be overlooked.