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e-EarlyCare-T

Specialized and updated training on supporting advance technologies for early childhood education and care professionals and graduates

MODULE II

Early neurodevelopment

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I. Introduction

Neurodevelopment is the process of acquiring skills in relation to the brain maturation of the nervous system in the child, until reaching the adult stage. It is a process where biological and environmental aspects intervene that are in constantand interaction. In this chapter, the neurodevelopmental processes of the nervous system will be reviewed from an evolutionary point of view to understand the emergence of the mechanisms of mental activity and human behavior in the child.

II. Objectives

Know the phases of brain maturation and the stages of acquisition of the different skills and abilities that will allow the child to develop correctly within the neurodevelopment process.

III. Specific contents of the topic

3.1. Brain development: Basic premises

With regard to brain development, the most widespread idea that exists today is that in the first years of life is when the complexity and functionality of the brain increases numerically. However, as Sebastian (2012) points out, a greater number of neurons and connections does not equate to better brain functioning.

As Ortiz (2018) expresses, this neurodevelopment will be a slow process that will last for several decades and will not have its parallelism with biological neurodevelopment. Brain development and maturation is characterized by long-lasting and heterochronic development**.** However, as brain structures develop, perceptual, motor, cognitive functions begin to be expressed in observable behaviors. Thus, structures that develop more quickly manifest their functions, rather than those functions that develop more slowly, such as the abilities controlled by the neocortex (frontal lobe) (Kolb and Whishaw, 2003., Coll, 2011).

Human beings are born with an immature brain devoid of a functional cognitive system and it is in fact that this immaturity will allow experience to shape this brain in a fundamental way.

And also, the different rates of maturation of the different cortical structures will be determined both by genetics and by specific stimulation mechanisms that are given to that developing brain.

In the first months of life, the cerebral cortex experiences a significant proliferation of synapses (neuronal communication) that will result in the formation of synaptogenesis, followed by a period of synaptic **pruning** (elimination of synapses, often due to lack of use).

Another element involved in brain development is related to the process of **myelination** of neurons, a process that consists of the axons of neurons being covered with a kind of "insulator" formed of white matter in order to have an adequate transmission of the signal.

And it is especially in this developing brain, the amount of myelin in a certain brain area will be a good indicator of the use that will be made of that area inducing the development of a certain cortical area with a certain involvement in a subsequent cognitive process.

As with *synaptogenesis processes and synaptic pruning processes,* myelination also *has different rates of formation depending on which areas of the brain are developing.* We would be talking, therefore, not only about how many neurons or synaptic connections exist, but also about how is the structure of white matter (axons and myelin), dendrites, as well as the neurochemical circuits that shape brain functioning.

Thus, it is presumed (Table 1) that both the **process of synaptic pruning** and that of **synaptogenesis** is determined by neurochemical mechanisms. The presence of certain molecules (specific brain areas) will enhance or slow down the appearance or disappearance of certain synapses, conditioned to the activity in neurons Sebastián Gallés, (2012).

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Table 1. Some features of human brain development Excerpted from García Madruga and Herranz Ibarra, 2010.

Characteristics of human brain development	
Postnatal growth of the human brain	Brain mass quadruples between birth and adulthood. -Notable increase in the number and complexity of neurons. -Steady increase in the density of synaptic connections in various regions of the cerebral cortex. - Increase in the myelination process which will allow an improvement in the speed of transmission of information between neurons.
Loss or "synaptic pruning" of synaptic connections	A process involving selective loss in brain development, mainly observed in synaptic density. Pattern of initial increase and subsequent decrease or "pruning" of synaptic density that appears at different ages according to different cortical regions. The initial overproduction of synaptic connections and the subsequent "pruning" seems to be related to the special plasticity of the infant brain.
Brain plasticity	Plasticity as a fundamental property of the development of the cerebral cortex. The process of differentiation and specialization of the different areas of the cortex is strongly influenced by the neuronal activity itself, in addition to the inherent factors related to the automatic "ignition". (Childhood and adolescence, mainly)

3.1.1 Prenatal and postnatal brain development

All the complexity of the brain derives from the precise spatiotemporal process of the main processes of brain development. (Figure 1). Both for *brain regionalization*, neural migration, and *synapse formation* by neural cells during the periods, embryonic and perinatal.

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The cells of the nervous system are formed from one of the three sheets into which the embryo, the ectoderm, divides during a process **called gastrulation.** The stem cells of the medial part of the ectoderm proliferate at an extremely high rate, modifying the morphology and size of this lamina and giving rise to the neural plate, forming the neural tube **(neurulation).**

The precursor vesicles, around the fourth gestational week, will form the three main structures that will form the future brain.

In turn, neural tube stem cells will be *future neurons and glial cells.* The cells that will become neurons will therefore lose their ability to divide and will be specialized cells. In order to form the different regions of the nervous system, the still immature neurons will migrate from the place of birth to their definitive location in the nervous system and once there, unite with other neurons to form functional units (nuclei and cortical layers).

Desarrollo embrionario		Desarrollo fetal					Etapa postnatal
1er mes	2º mes	3er mes	4ºmes	5ºmes	6º mes	3er trimestre	Nacimiento- adultez

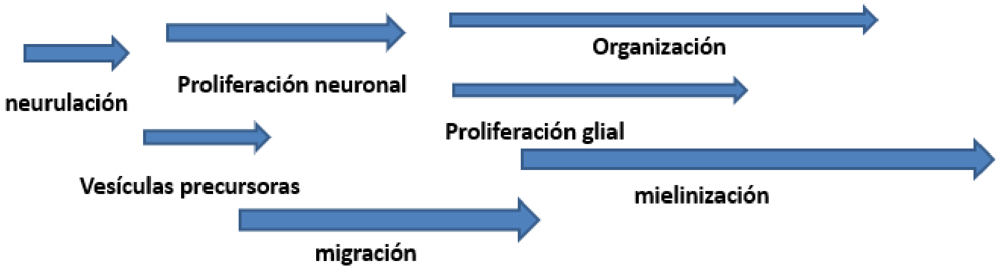

Figure 1. Temporary windows of the development of the nervous system. Enseñat et al, 2015

With respect to **proliferation**, also called **neurogenesis**, a process that occurs between the third and fifth month of fetal development, which consists of the miotic division of stem cells in the neural tube to later produce neurons and glia.

Parallel to this process, **cell migration** also occurs, which are massive movements or displacements of nerve cells, or precursor cells in order to establish differentiated populations of nerve cells (layers of the cerebral cortex, subcortical nuclei). It seems that some supporting cells (glia) help guide this process of cell migration.

The formation of synaptic connections (inaptogenesis) takes place at various times throughout development. During the last months of intrauterine life and the first years of childhood, an extraordinary high number of synapses will be formed, but many of these neurons will disappear, while new synapses will be formed and the functioning of existing ones will be modified. This process is called **synaptic reorganization,** being key to the maturation of the brain and the consequent evolution of mental abilities. These synapses will depend to a large extent on the pattern of electrical activity of the neurons and this in turn will be related to the use made of these synapses.

In order for immature neurons to develop the functions that define them (processing of chemical and electrical signals) they must acquire specific electrophysiological and biochemical properties and establish synaptic contacts with other neurons. These immature neurons must be able to generate and conduct nerve impulses (**action potentials**) capable of releasing certain types of neurotransmitters (chemicals that serve to communicate and cause one effect or another) and to respond to messages emitted by other neurons.

Before the formation of these synaptic connections, it is necessary that the axon is formed, an extension that arises from the cell body and that increases its length until it reaches the region that contains the target neurons with which the synapses will be established. It is also necessary to form dendrites (neuronal extensions specialized in the reception of information).

At various moments of development and following (Coll, 2011) and very markedly in the perinatal stage, an apparently paradoxical process also takes place, which is **cell death or apoptosis**.

This process involves the death of many neurons that had been formed in previous stages as a result of the expression of genes that will activate programmed self-destruction. This process is most likely activated in those neurons that have not been able to establish functional synapses and in turn has not been nourished by neurotrophic factors (proteins that ensure the survival of these neurons) the formation of synaptic connections and synaptic plasticity.

Thus, during the development of the nervous system, a significant number of neurons will be generated, some of them selectively eliminated. A very large number of synapses will also be formed and will subsequently undergo a reorganization process.

These phenomena of **synaptic reorganization** and apoptosis will end up configuring the nervous tissue with fewer neurons and fewer synapses than those initially formed, but a more efficient functioning (Coll, 2011).

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Postnatal development

In general, the development and maturation of the brain is characterized by being of long duration and by occurring at different times. Thus, various aspects of development will take place not only throughout childhood, but also during and even during adolescence. In general, regions related to more basic sensory, motor, and physiological functions mature first, while areas related to complex cognitive functions show a slower maturation process.

Also, maturation changes in brain tissue during childhood and adolescence show a reduction in gray matter volume and an increase in white matter volume. Gray matter consists of the parts of nerve tissue that are composed of neuronal bodies and dendrites, in addition to most synapses, while white matter is basically made up of nerve fibers (axons).

From the last months of gestation until approximately two years of life, there is a very notable increase in brain synapses, which will be reduced, reflecting a reduction in the volume occupied by the gray matter. This reduction is the product of synaptic reorganization processes that improve the efficiency of brain functioning. In turn, the increase in white matter volume is attributable to increased myelination of axons.

In some regions, especially in areas related to so-called executive functions (planning capacity, inhibition of irrelevant thoughts, management of emotions and monitoring), this myelination process takes place well into the third decade of life (Coll, 2011).

3.2 Anatomical neurodevelopment

As we have seen above, the development and maturation of the cerebral cortex and in turn of the CNS will be evaluated by means of different criteria: *myelination, axon* development (proliferation of axonal buttons) dendritic *arborization*, measurement of neurodensity (development of *dendrites and cell bodies) and measurement of the thickness of the cortical layers* (it will show us the degree of complexity, neural networks of the cerebral cortex) (Guinea, 2003).

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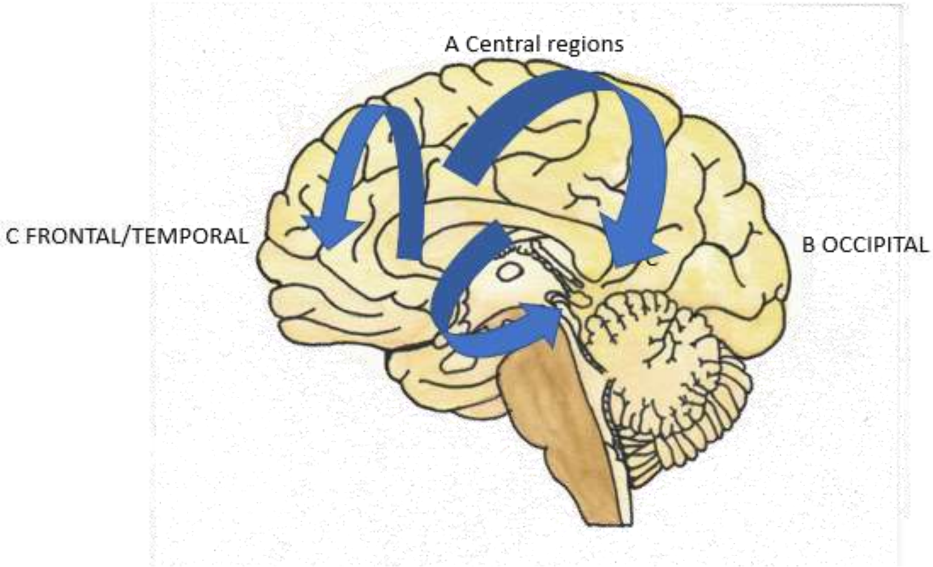

Figure 2. Cortical myelination patterns. Based on Enseñat et al., 2015

As we are pointing out previously, the emergence of these cognitive functions will be given by the process of myelination (figure 2). First, the sensory and motor areas (parietal area) will be operational, then, the development will continue towards visual areas, located in the occipital lobe, to finish, as we have been developing throughout this chapter, the coordinated executive functions in the prefrontal lobe. Thisprocess occurs in **a sequential and hierarchical manner,** following coordinated steps in the development of the following neuroanatomical structures.

1.Brain stem and reticular formation: In these brain structures are the centers that control wake-sleep rhythm, breathing movements, cough reflexes, sucking, swallowing, blood pressure, cardiac movements, and the primary autonomic functions of life. First structures to develop vital for survival.

2.Thalamus: The pulvinar nucleus grows rapidly between 16 and 37 weeks of gestation. Thalamic afferents can already be observed at 82-91 days towards the prefrontal and occipital cortex and later, between days 145-150 there is a relatively mature pattern of thalamus-cortex projections but whose branching is more extensive than in the adult.

3.Basal ganglia: These structures play an important role in controlling posture and voluntary movement. Theputamen develops at a faster rate than the caudate nucleus in the first four and a half months of gestation. The first synapses are already observed in the putamen at 60 days and at 65 days in the head of the caudate nucleus.

These two structures, both the *putamen and the caudate nucleus*, are structures that make up the basal ganglia, fundamental structures along with the thalamus, cerebral cortex, and cerebellum, which are responsible for motor control. It should also be noted that the first afferents from the brainstem and the substantia nigra will arise around 40 days and those from the prefrontal cortex will appear around 70 days.

4.Hippocampus: The development of this brain structure begins around 38 days and is practically simultaneous in all areas. In the second half of hippocampal gestation, well-differentiated postsynaptic elements are already shown, and the established afferent pathways are already generated.

5.Cerebellum: At the beginning of the fifth month of gestation a six-layer cortex is observed in the area of the vermis and in the medial areas of the cerebellar hemispheres, with a slower development of the lateral faces of the same (about one and a half to two months). By six months all cerebellar areas have six layers, although the embryonic granular layers do not disappear completely until seven months or eight months after birth. Until the second year of life, the cerebellum grows rapidly to reach adult size between six and nine years of age.

6. Primary motor and sensory areas: the maturation of the layers of the motor cortex begins at birth and its development will allow reflex and spontaneous movements of the limbs, although it will still take longer until the baby can perform coordinated movements.

7. Secondary motor and sensory areas: the maturation of these areas may coincide with the maturation of the primary and tertiary areas, although the development of this area is slower and will end around the fifth year of life. With the maturation of the secondary areas, the process of lateralization of functions and the passage from the sensory-motor level to the perceptual motor begins. These regions are essential for learning during the first years of life.

8. Tertiary and posterior areas of the cerebral cortex: These are areas that correspond to an area of integration of stimuli of different sensory modalities and production of symbolic functional schemes. The maturation of these areas is key to the acquisition of school knowledge, highlighting the angular gyrus of the parietal lobes, essential for the acquisition of reading.

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9. Prefrontal cortex: Part of the cortex that is to develop last. It will not be fully functional until four to seven years of age and will continue its development into adulthood. Also called neocortex.

The process of differentiation and specialization of the different areas of the cortex is strongly influenced by the neuronal activity itself, in addition to the inherent factors related to the automatic "ignition".

3.3. Functional Cognitive Neurodevelopment

The development of the main cognitive functions depends on the maturation of the brain circuits that support it. Knowing the evolution and normal development of cognitive functions will be essential to identify and interpret possible alterations in this development. The study from the nEuropsychology focuses on the study of the main cognitive processes that will be established as the nervous system develops. We will talk about the maturational development of perception, memory, attention, language and in its entirety the development of executive functions. (Enseñat, Roig and García, 2015).

3.3.1 Visual perception

In general, it is accepted that during the first year of life the visual system undergoes important functional changes (both for oculomotor regulation and for visual acuity) showing functional changes that depend on the subcortical structures at first, and then move to the progressive domain of processing at the level of the cerebral cortex.

With respect to the two pathways responsible for the processing of movement, shape of objects, places and faces (ventral and dorsal pathways), the *ventral* way is responsible for the processing of shape, while the dorsal way, the processing of movement.

Integrated response to movement is considered to be earlier than integrated form processing. However, the first thing that will be processed are the faces, objects and places. Movement processing, however, will take longer to reach maturity and appears to be more susceptible to alteration (Enseñat et al., 2015).

One of the most studied visual processes in childhood has been the *recognition of faces*. All the evidence accumulated through research in this area leads us to conclude that already at the age of 5 years or perhaps earlier, maturity in the perception of faces is already reached, partly due to genetic mechanisms and innate contributions.

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Therefore, it could be considered that in childhood, the adult mechanisms employed in the perception of faces are already present. This would include phenomena associated with the recognition of individuality and learning of new faces, global processing, as well as the acceptance of the absence of certain traits, but managing to recognize that previously coded face. (Enseñat et al., 2015).

In addition, it should not be forgotten that the maturation of other cognitive processes will also contribute to improving the recognition of faces beyond early childhood, as well as, for example, the recognition of faces will improve if we join the development of recognition of emotional expression, related to changes in the connections between neuroanatomical structures such as the fusiform gyrus and the structures of the limbic system (amygdala, hippocampus).

3.3.2. Memory

The age at which you reach mnesic maturity will depend on several factors. On the one hand, it will be mediated by the development of coding strategies dependent on the maturation of the prefrontal cortex, and by the development of the mnestic process associated with the maturation of the medial temporal lobe.

This will have as a consequence the increase in general knowledge that will necessarily improve the ability to memorize. As Enseñat et al. (2015) expose, another factor that influences is the development of basic cognitive functions such as processing speed, attention, working memory capacity and the effect of complex functions such as the ability to solve problems or metamemory (Enseñat, 2015, Ofen, 2012).

Episodic memory is considered to develop throughout childhood, but it is not clear whether maturity is reached at a certain age or, conversely, continues to develop throughout development until adolescence.

With regard to the development of coding strategies, in those cases in which the tasks involve greater complexity and require the use of certain strategies to obtain a free memory or greater involvement of a temporal order, they will entail a later development. (Frontal lobe vs occipital lobe).

On the other hand, if we consider the relevant role of the medial temporal lobe for memory processes and the scarce structural changes of this region from childhood, it could be considered that the processes involved in memory more related to the medial

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temporal lobe, such as associative memory, They would be the ones who would mature earlier (Ofen, 2012, Enseñat et al., 2015).

In its entirety, the evolution of episodic memory emerges from the development of a brain network that includes, at a minimum, the hippocampus, and the prefrontal cortex. The role of the parietal lobe in the development of episodic memory is not so clear and it is suggested that it can function as a mediator due to the involvement of attentional processes.

With regard to procedural memory, necessary for complex thinking, we know that, from an early age, children already acquire procedural skills that will later serve them in learning new skills. The age of acquisition will depend on the skill required, the times that what is memorized is repeated and the requirement of other cognitive functions to be able to carry it out. It is considered that procedural learning first goes through a more external phase, in which cognitive resources (short-term memory) are needed so that it can progressively convert this type of procedural memory into an implicit and automated memory in which this procedure guided by external data is reduced. However, it seems difficult to explain through this approach all procedural learning in children in whom the mechanisms of explicit learning and cognitive control have not yet been developed.

On the other hand, working memory refers to the ability to maintain and manipulate for a short period of time the information necessary to guide a certain behavior. In general, it is considered that this capacity experiences a significant increase at 11 years, as well as between 15 and 19 years, reaching maximum levels in adulthood. Its correct development has been related to the maturation of cortical areas such as the superior frontal cortex, the intraparietal cortex, as well as their connections.

The development of different types of memory provides the basis for the acquisition of skills and knowledge of the adult. Knowledge of milestones reached during childhood not only provides useful information for clinical evaluation but will also have important implications for education.

Considering that children's episodic memory is basically associative (at least until primary education) is essential to consider it necessary to instruct them in the use of specific strategies to improve memory performance in the classroom. Enseñat et al. (2015).

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3.3.3. Language

With regard to language and its cognitive development in childhood, language acquisition, as well as the acquisition of other cognitive functions, will depend to a large extent on the level of environmental stimulation and correct brain maturation (Enseñat et al., 2015). The proper development of language systems depends on interaction with other functional networks responsible for ability, e.g., motor, or visuospatial skills, memory, attention, acoustic discrimination capacity and social and emotional skills.

A classic example to illustrate the existence of critical and sensitive periods is the study concerning language acquisition. It is important to note that not all aspects of language are acquired in the same time windows. We know, for example, that the critical period for learning phonemes will occur during the first year of life. Soon after birth, babies are already able to discriminate the phonetic contrasts of different languages, even those that contrasts not present in their native language. (Enseñat et al., 2015).

The exposure to a linguistic context during the first year of life will allow the specialization of this skill, achieving better capacity for the phonological contrasts of the languages present in their day to day. (Language period).

During the following months, the child learns an average of 10 words per month to exceed the figure of 50 words, later, about 18 months the explosion of that vocabulary is evident, and the child is already able to learn an average of 30 words per month. (Enseñat et al., 2015).

Around the second year of life, between 18 and 36 months of life, syntactic learning begins. The child is already able to make and combine words in simple grammatical structures (sentences with two words) and later, around the age of five, children will increase the complexity of these grammatical structures that they use to add the use of negative questions and phrases.

The complexity of grammatical structures will not be dependent on the availability of lexical content and therefore will be related to the child's ability to increase their vocabulary.

From the age of five, children already begin to experiment with the uses of language, so that communication strategies and keys appear that will allow them to follow a conversation with another person, clarify misunderstandings of a speech, increase their level of understanding as well as narrative production. (Enseñat et al., 2015).

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3.3.4 Executive functions

Executive functions (EF) refer to a set of cognitive functions that allowmaintaining a coherent and organized plan towards a specific end. These functions include the ability to plan and organize information, flexibility and planning, and the ability to control impulses (Roselli, 2002).

In general, it is considered that the most critical regions for the emergence of executive functions are located in the prefrontal cortex, in the most anterior part of the frontal lobe, in front of the motor areas. The prefrontal cortex and the connections that this region establishes with other brain areas undergo changes not only throughout childhood, but also, very markedly, during adolescence. Coll, 2011.

FEs include cold executive functions as well as hot executive functions. *The first refer to the ability to plan, organize, set goals, monitor behavior, solve problems, inhibition, working memory and cognitive flexibility*. The latter include empathic capacity, emotional regulation, theory of mind and decision-making capacity with an affective component, skills necessary to regulate our behavior with a purpose (Enseñat et al., 2015)

The development of the **prefrontal lobe begins in the prenatal period**, with subsequent metabolic and structural changes during childhood and adolescence but does not reach its evolutionary maturity until the thirties, when myelination is terminated.

There is an early maturation of attentional control and some working memory capacity, while other more complex skills such as planning and organization are acquired during adolescence and adulthood. Attentional control (selective attention, response inhibition, self-regulation, and self-supervision) is the first element of executive function to mature. Evidence regarding goal setting (planning, goal setting, and problem solving) during childhood age is scarce. By age 5, children can set goals and plans.

And finally, in relation to the ability to make decisions with an affective component, we know that children from 3 to 6 years old rely exclusively on immediate rewards. It is not until adolescence, when you begin to make decisions in an effective way.

This ability has been associated with late maturation of ventromedial and orbitofrontal prefrontal areas and appears to be independent of the improvement in inhibitory control and working memory that will occur at the same stage of development. (Anderson et al., 2008. Enseñat et al., 2015).

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3.4 Brain plasticity in child brain development

The CNS has a remarkable ability to modify its function and to some extent, modify its anatomical structure in response to activity, environmental stimuli or damage that may suffer. Plasticity is a constant process, which can be observed in different areas: synaptic, structural and organization of neuronal maps. (Medina et al., 2004). As a general rule, we can affirm that changes in behavior that are described (according to circumstances) such as learning, memory, habits, maturation, recovery, and others, are associated with corresponding changes in the nervous system.
The concept **of 'neural plasticity'** refers, under normal circumstances, to the ability of the nervous system to model its structure and function according to experience, which gives rise to learning processes. And in circumstances of pathological loss, to its ability to try to update the potentialities of the individual genetic program through remodeling phenomena.
This brain property can be assessed on many levels, from observable changes in behavior, brain maps, synaptic organization, physiological organization, and molecular structure.
To understand processes such as memory and habits, it is necessary to understand the nature of brain plasticity. The genomic endowment allows, therefore, a margin of adaptability when handling information and also when attempting anatomofunctional compensations after suffering some pathogenic aggression. (Narbonne et al., 2012).

3.4.1 Types of brain plasticity

Learning and remembering new information is linked to some kind of change in the cells of the nervous system (neurons). These changes are considered to constitute the neurological record of learned information. As shown by Grenough and Black (1992) and Coll (2011)
It is possible to establish, summarizing three major types of plasticity: that of development, which induced by experience during life and finally, that induced by damage, loss of afferents or alterations in brain activity.

1.- Plasticity experience-expectant. (Expectant plasticity of experience)
This type of plasticity involves synaptic changes produced by aspects of the environment that are common to all members of the species and expected at certain times of development. (experiences).

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As we have seen above, thereis initially an overproduction of synapses, followed later by neuronal loss (Coll, 2011).
This type of plasticity is limited to periods of maximum susceptibility during development to certain environmental variables **(critical or sensitive periods).** After this time window, the influence these experiences have on the brain and its connections will be much more limited. Therefore, the selection of the organization pattern of the SN will be permanently and sometimes irreversibly completed.
This mechanism allows genes to encode the nature of the connections to be established, already from the fetal period and later in the postnatal period, where it is "expected" that the child will experience basic episodes, common to the entire species, such as exposure to light and sound, to preserve the previously established nautical connections of the perceptual systems, of sight and hearing. (Siegel, 2016).
2.-Plasticity experience-dependent. (Experience-dependent plasticity).
The second type of plasticity reflects changes produced by information absorbed from the environment that may be unique to the particular individual, (vocabulary-specific learning) that are experiences throughout the life cycle.
*This plasticity is not limited to fixed periods of time***.** **This type of plasticity is maximum during childhood and adolescence.** It is maintained throughout life, except for the presence of neurodegenerative diseases or neurodevelopmental disorders.
It is triggered by the detection of relevant relationships between relevant stimuli between stimuli (learning and memory) or alterations in the stimulating situation (injuries, loss of limbs). This type of plasticity exclusively activates the genetic machinery to create synapses, whose creation undoubtedly depends on that set of experiences that have previously triggered the creation of these synapses. This type of plasticity is temporary and subject to change depending on experience. (Siegel, 2016).
3. Plasticity independent experience:
It responds to changes in the number and/or function of synapses that occur as a result of the programmed expression of certain genes without external or experiential factors. This type allows an optimal adaptation of behavior to the changing environment. These experiences are an endorsement of techniques that are based on sensory stimulation and learning, although this effect (increased synapses in the cortices involved in learning) is especially noticeable in the "sensitive" or critical periods of early development, although they are also demonstrated in the adult brain (Castaño, 2002).
At present both terms are still used, but sometimes "experience-dependent" is used exclusively to refer to both the plasticity of development and the plasticity present in the rest of life.

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Summary

This chapter has addressed the main concepts of early neurodevelopment, both from the neuroanatomical point of view and from the functional point of view. The main neuroanatomical processes involved in the development, cognitive, motor, affective and functional of the child have been analyzed. As well as the phenomena of brain plasticity, involved in this neurodevelopment.

Glossary of terms

Apoptosis: consists of causing the programmed death of different cells. This process arises as a result of an adaptive development to achieve an efficient nervous system.

Cell migration: Mass movements or displacements of nerve cells, or precursor cells, in order to establish differentiated populations of nerve cells (layers of the cerebral cortex, subcortical nuclei) it seems that some supporting cells (glia) help guide this process of cell migration.

Differentiation: The process by which cells become more specialized. In the early stages of embryonic development, cells are similar to each other, but they specialize later and acquire specific characteristics as they are part of different structures of the nervous system.

Heterochrony: biological process that encompasses all those changes in the rhythm of ontogenetic processes that give rise to transformations in the shape and size of organisms.

Myelination: coating of axons with a myelin sheath in order to allow adequate transmission of nerve impulses.

Neurogenesis: or also called proliferation, a process that consists of the miotic division of stem cells in the neural tube to later produce neurons and glia.

Neurulation: Anembryonic mechanism in which the neural tube is formed.

Ontogeny: The study of the individual development of an organism.

Phylogeny: The historical and generic development of a species, i.e., how a species has changed over time

Synaptic pruning: A process of elimination of synaptic connections that the brain does not use during the developmental stage that takes place in two evolutionary moments; in childhood and adolescence.

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Action potential: Oran electric discharge that travels along the cell membrane modifying its distribution of electric charge. Necessary to perform the electrical synapse and subsequent chemical synapse.

Synaptogenesis: The establishment of synaptic connections as neuronal tissue develops and axons and dendrites grow.

Synaptic reorganization: Loss of some synapses and the development of new ones in order to improve the efficiency of synaptic connections.

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