NEURODIDACTICS AS A TRANSDISCIPLINE FOR A LANGUAGE PEDAGOGY OF SPANISH LANGUAGE. THE *ENTORNO* AS THE NEW NATURE-BASED EDUCATION

NEURODIDATTICA COME TRANSDISCIPLINA PER UNA PEDAGOGIA LINGUISTICA DELLA LINGUA SPAGNOLA. L'*ENTORNO* COME NUOVO APPROCCIO EDUCATIVO *NATURE-BASED*

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ABSTRACT
The statement about Neurodidactics as a transdiscipline enhanced the research in the field of language pedagogy with particular attention to Spanish language learning as FL. In line with the contrastive-perceptive language model, this paper explores the dynamic relationship between brain and language, focusing on the play of the environment (*entorno*) as the main component of nature-based education addressed to beginner learners.

La definizione di Neurodidattica come transdisciplina ha incentivato la ricerca nel campo della pedagogia linguistica con particolare attenzione all'insegnamento dello spagnolo come LS. In linea con il paradigma della linguistica contrastivo-percettiva, il presente lavoro esplora la relazione dinamica tra cervello e linguaggio, ponendo l'accento sul ruolo dell'ambiente esterno (*entorno*) come componente essenziale dei contesti educativi *nature-based* rivolti a studenti principianti.

KEYWORDS
Neurodidactics, Spanish learning, contrastive-perceptive language, enactive approach
Neurodidattica, lingua spagnola, linguistica contrastive-percettiva, approccio enattivo

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1. Neurodidactics as a transdiscipline

The latest research has been increasing the number of publications about the role of Neurodidactics in the context of education. Nowadays, human brain is the focus of a variety of studies to reveal the benefit it provides during the act of learning. Thus, the notion about assuming the brain like the core of new teaching methodologies offered an improvement for teachers and, on the whole, for education. Although, it has been argued (Gola, 2025) an overuse of this assumption according to which there may be the risk of falling into the trap of a scientific dualism between people and neurons (Gola, 2025: 13). To some extent, should the scientific community consider this as a progress or a decline? It is crucial to trace back to the origin until when this new discipline came to light. Originally, the rise of new methodological paradigms in the early 80s of the last century – such as Neuroscience, Cognitive Neuroscience, Neuropsychology, Neurolinguistics – were able to overcome the boundaries of the traditional thinking which considered didactics as a "mere transmission of content from the teacher to his/her students". However, this statement took for granted the idea of the learner as a human being endowed with a brain, a body and emotions. Since Tokuhama-Espinosa (2011) and other scholars gave their contributions to "shift" the perspective of traditional teaching, it was estimated an overturning of mindset. The idea was to talk about students as "a network of neurons" (López García, 2014): the individual is the result of a complex network of synaptic connections made of an input which comes from the outside to be converted into an intake inside our black box, the brain. Though, what are the benefit of the synaptic mechanism? Thanks to one of the main properties of mind – the plasticity – it helps individuals to develop their learning process.

Anyway, Garces (2022) stated that researchers should focus not only on the mental efficiency but instead to fix the human being as a whole according to a holistic view. For this reason, how could neuroscience be filled into education? Gola (2024) coined the term "Neuroumbrella" to establish the *fil rouge* between neuroscience and education. He considered the field of education as a cross-disciplinary approach which fosters a deeper understanding of learning and teaching; in this perspective, Neurodidactics represents the hub among Neuroscience, Psychology and Education. This paper aims to employ a neuroscientific approach. But, how could Neuroscience be necessary to pedagogy, linguistics and other disciplines? This is due to the fact that to know the grammar brain implies to know the

individual neurobiological processes whose results can lead to a "natural" development of its cognitive abilities in education. So, the Mind, Brain, Education (MBE) approach offers a more comprehensive framework (Gola, 2024: 3) as a transdisciplinary perspective. In other words, Neurodidactics may be portrayed as the central axis of a circle establishing a link among the already mentioned Neuroscience, Psychology and Education (Fig. 1).

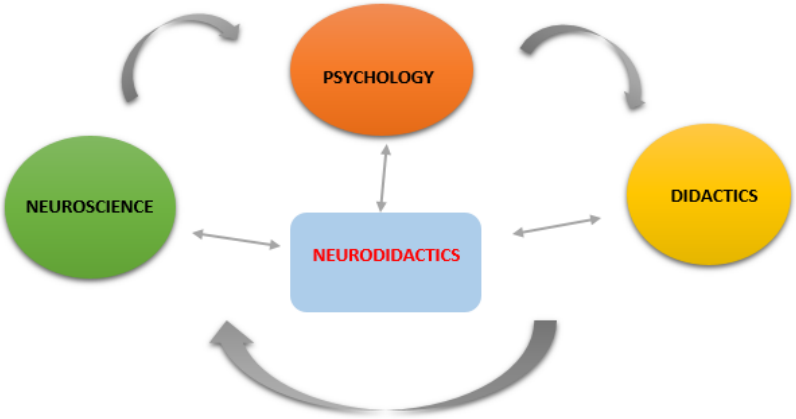


Figure 1. Neurodidactics as a transdiscipline

Thus, Neurodidactics allows to establish a path in which brain, body and environment are interconnected. Indeed, there were built different labels to spread the vision of a conscious learning in which disciples have to be aware of their learning processes: Educational Neuroscience (Thomas et al., 2020), Neuroeducation (Battro et al., 2008), Neuropedagogy (Houdé, 2006) and so on. In addition, Gola (2024) in his latest essay – *Educational Neuroscience in the classroom* – proposed a turning point of the common vision of education. According to him, it is essential to make students conscious of what happen in their brain when they are learning and it is crucial that teachers may know consciously teaching processes as well; for this, he brought to light the philosophy of applying Educational Neuroscience in the context of classroom to create a "neural" place where the relationship between teachers-students is seen as a neural networks system. By

this time, this contribution would adopt the network-based theory taking into consideration the possibility of the brain to communicate among its different areas.

On the heels of Gola, Compagno and Di Gesù (2025) marked the same path moving beyond the "uncrossable boarders" of Neurodidactics and, in particular, brain and language connections. As Di Gesù stated human brain is the smartest learning workshop (2025: 107) and how huge and deep it is; hence, it is unbelievable to build only a singular learning method because of the fact that each student has its own cognitive style and a specific cultural background. The aim is to recognize neural mechanisms which regulate acquisitional and learning processes to improve the study of a foreign language – like Spanish. In this view, language becomes one of the blocks to create those *trait-d'union* between neuroscience and cognitivism. About Neuroeducation, Tokuhama-Espinosa (2010) was one of the former who labelled it as a sum between Mind, Brain and Education (MBE), as well as being transdisciplinary discipline, MBE is a cross-cultural entity […] (2010: 34). This is the starting point to assume Neurodidactics as a transdiscipline during Spanish learning process.

2. Language pedagogy of Spanish language from a contrastive – perceptive paradigm

The conception of studying a foreign language does not fit with the acquisition of other educational subjects. Generally speaking, scholars and teachers have not to take for granted that learning disciplines such as history rather than languages could not get the same teaching methodology: they ought to be aware that in the first case, almost these kind of subjects are taught in students' mother tongue, on the other hand, in the second one, acquiring another language – with different language pattern – may provoke some bias to the learning process. As a consequence, education in the linguistics field implies a variety of external factors to take into account: emotion, environment, students' character and above all their genes. Indeed, the neurobiological framework enables to submit some general guidelines for native, second and foreign language teaching (Daloiso, 2009: 34). The main parameters to focus on is the emotional aspect: neuroscientifically speaking, there are some brain areas enrolled with the emotional task – such as the amygdala – from which might depend the benefits or not of language acquisition. But, how could these external phenomena affect the whole disciples' learning mechanisms?

How could teachers act as a filter to avoid any potential outdoor “distractions” to students for their improvement?

Thanks to the contributions of Preiss (1988), Herrmann (2006), Gola (2024) and Rivoltella (2012, 2024), it can be set the foundations for assuming Neurodidactics as an intersection between the intention of creating an interdisciplinary field and the coding of educational research section “neuroscientifically” based (Di Gesù, 2025: 110). In light of this, teachers should reset their mind and changing their point of view, focusing not only on educational goals but also on students’ skills. To think on learners as an amount of brain area cooperating each other to the creation of a self being, it may be noted how far education could reach. Teaching a foreign language is not a mere transmission of codes from one language to another but instead, is conveying a system of meaning between the two languages involved in a specific culture and a specific context. It was estimated that the majority of brain regions were developed during pregnancy; however, the cortex grows up afterwards, during childhood. This implies what linguistics stated as the “critical age” of individuals to learn a language. Due to the fact that human cerebral areas enhance language abilities just for survival since they were born, past studies have claimed the critical age until 11 or 12 years old as the age until when students could learn another language apart from theirs. How could scholars state that? According to Neuroscience, human brain results totally evolved in this age range. What does it mean? Does it mean that after this “critical age” individuals are not able to learn another language as a bilingual? And, what happens in the case of a native bilingual? Would they be affected from language disabilities?

Daloiso (2009) stated that it exists two categories of bilinguals: native bilinguals and late bilinguals. The former are those who can access to their cognitive – conceptual system directly and separately through two different languages avoiding any form of “mental translation”. The latter are those whom conceptual system is indirectly connected to foreign language where mother tongue acts as a filter. Should education find other methodologies considering the difference of students’ cognitive style or separating bilinguals into two groups? Would be unreachable for late bilinguals to become native one? Does Native language as a filter provoke a positive or a negative feedback?

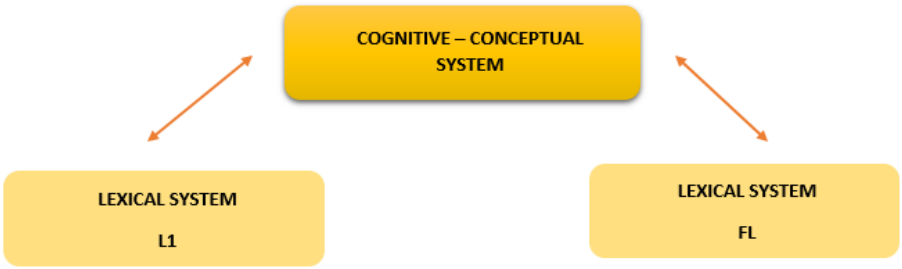


Figure 2. Lexical Systems and Conceptual System in native bilinguals

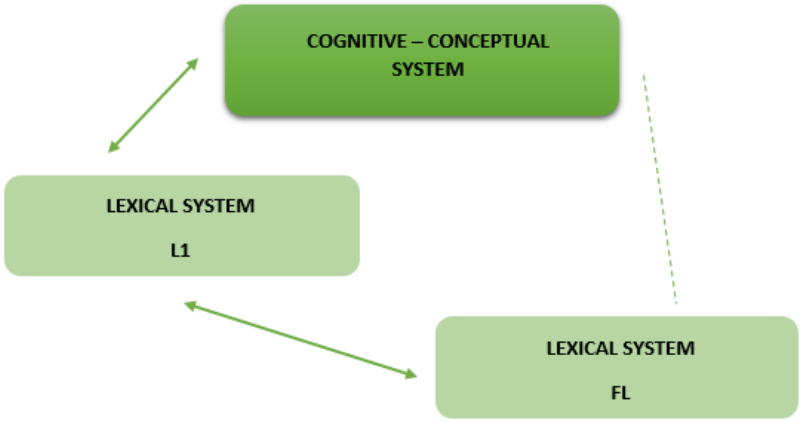


Figure 3. Lexical Systems and Conceptual System in late bilinguals

At this point, like on stage, it comes into play an alternative approach capable of eradicate the supposed conventional way to teach in favor of a contrastive – perceptive linguistics. The *Neuroscience Dictionary* (2004) describes learning as «the process an entity realizes with experiencing and it modifies its attitude permanently»[1]. It is closely related to memory mechanisms, changes of brain plasticity and synaptic activity (See chap. 3). Learning may be seen as the result of

[1] The concept of "experiencing" is connected with the engagement of external factors such as environment implied both in learning and teaching processes widely described in chapter 4.

the creation of a potential memory activated by an input, which the interaction with environment may boost or block (Di Gesù, 2012). Therefore, language acquisition is a neural process which allows the creation of new synaptic connections. Paradis (2004) found out four neurofunctional patterns that control separately: linguistics competence, metalinguistic competence, pragmatics competence and emotional dynamics. The purpose of this paper is using this paradigm to overcome traditional educational methodologies. Hence, Contrastive – perceptive linguistics was born in the 40s and 50s of the last century to study the contrast between two language systems. In this approach, learning was conceived as the result of attempts and errors in order to find the right answer and, consequently, stimulating a positive feedback to let the disciple save the contents as its own habits. In his article *The Significance of Learner's Errors* (1967), Corder gave birth to a new method which rethink errors in a positive way.

Furthermore, this new paradigm takes a Neurodidactics advantage: to use brain neurophysiological model to settle specific standard concepts. Integrating Neurodidactics with Contrastive – perceptive linguistics implies benefits for memory and mental categorization. What does it consist on? The hypothesis is that to facilitate the settlement of a concept, our brain works to create a group of mental lexicon when the student need to recover it from stocks. In this specific case, the two language systems involved are Spanish and Italian: they are too similar because of their cultural background – they have in common Latin as their native language – phonetics and a lexicon which allows speakers to understand each other. Although, being too much similar might cause some disadvantages at a lexical level such as "false friends", consisting in the homonymy of some words which have a completely different meaning. For this, when beginners – students who study Spanish at their starting level – learn Spanish they may have some problems of misunderstanding and their MT as a filter becomes an interference and consequently causing a positive or negative transfer in the target language system (FL). As a matter of fact, Vedovelli (2001) planned three levels of linguistics competence of any disciples: phase of pre-basic, basic and post-basic interlingua. With the terms of "interlingua", Selinker (1972) defined these steps in which learners activate a psychological latent structure, it means temporary systems that allow to build the real system of a foreign language. In detail, pre-basic phase is focused on the "pragmatic mode", which is the use of communication, body language and external context. The basic and post-basic phases are "syntactic

oriented": in the basic one, it develops the use of morphology and the construction of simple sentences; in the post-basic one, there are complex sentences, lexicon and syntax play a crucial role. To what extent Contrastive – perceptive paradigm is in line with Neuroscience thought? Luque Durán (2004) and López García (2014) were essential to focus the neurolinguistics vision: from one hand, Luque Durán stated that elements which form language lexicon organize themselves in a mental area like big cognitive networks interconnected each other […] (Durán, 2004: 229). Words are not mere linguistics signs of real word but they reflect mental representations of inner concept and culturally based (Di Gesù, 2025: 150). From the other hand, López García (2014) located lexicon and syntax in specific brain areas like limbic system (the unconscious side) where there is syntax and cortex (conscious side) where there is lexicon; in the middle of these regions words form complex networks. How could categorization be figured out as a teaching methodology? Because to categorize implies a mental operation to connect an external image with its inner representation to build a "mental reasoning lexicon" where students are aware during their learning process.

Di Gesù (2016) gave birth to a minimum contrastive – perceptive lexicon-grammar based on the detection of a conceptual area for every family words of Spanish language but in line with Italian learners' need. The follow image reproduces the passage of an input from an external context enter and be filtered in our brain as a mental representation to activate a metalinguistic reflection.

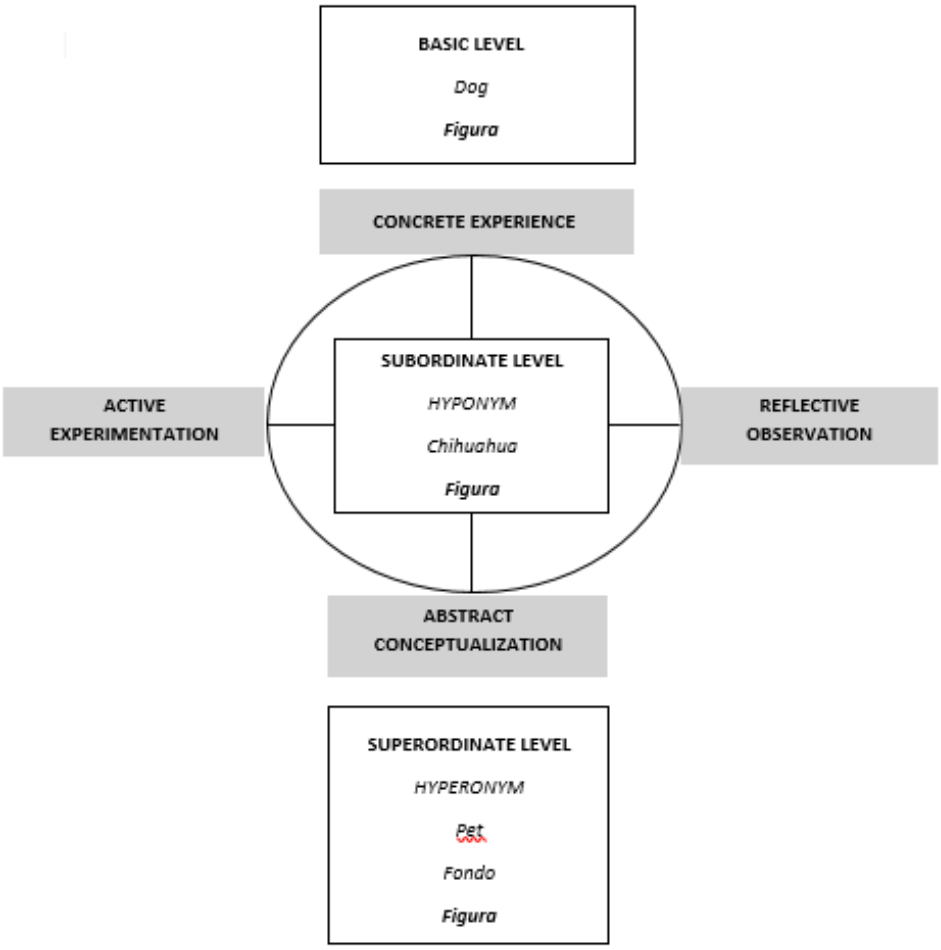


Figure 4. Kolb's Model Application to Categorization and Contrastive-perceptive linguistics (Di Gesù, 2019)[2]

2.1. Learners of Spanish language: the beginners

In conformity with a contrastive-perceptive outlook, mentioned in the former paragraphs, cognition and language have to be deemed like a dynamic phenomenon rising up from the integration of body, environment, culture and

[2] For further reading about this content let seek to Di Gesù's contribution *Linguistica contrastive-percettiva di lingue tipologicamente affini: italiano e spagnolo* (2016).

action (Di Gesù, 2025: 161). This is because of students' background they include – unconsciously - with themselves during their learning process. As a matter of fact, it is necessary to distinguish the several learners' age levels; the first level is for beginners (A1/A2)[3], who start learning Spanish for the first time. The second level is intermediate (B1/B2), where students begin to explore in deep this language; the third one (C1/C2) is the step where students can be considered near-native speakers of the foreign language (FL). This paper proposal is to take into account the beginners level to analyze how brain – language – body can interact. Why them?

López García (2017) claimed: el lenguaje es una realidad de dos caras, sirve para comunicarse y para conocer el mundo, es decir, tiene una dimensión social y una dimensión mental (2017: 56). Through his statement he would show language identity and its communicative, social and mental functions; thus, language is both a social and cognitive ability. In every context language is used as a means of survival: the intention is to choose these specific learners at their initial level because they do not have any tools to use and practice Spanish language on their own and so they rely on the context try to make their conversation clear without being confined to isolation.

3. Brain: a language code in an "enactive" context

The concept of integrating the duo mind-brain (following Brain-based studies) it is the new path for improving educational research. What are these neural mechanisms behind the educational process? Why do we consider neural activity at the basis of education? Whether language has its minimal unit – word – brain has its own, the neuron as well. The following statements propose a comparison to behold to what extent brain and language have in common to give a "social status" to the relevance of brain learning in schools. Thus, neurons are formed by a cellular body, soma, extensions, dendrites and axons; it works like a real central station where communication is required. The possibility to communicate is due to the receptive action of dendrites and philanthropic activity of axon which enables the passage of information to other neurons in the shape of electrical stimuli creating functional contact points among neurons, they are synapses (Compagno, 2025: 28). At the same time, language needs its lexicon-semantic unit to shape a communication and brain has its neural language to establish interconnections

[3] In accordance with the European Framework of reference for languages

among brain area and, transfer them to real world. To communicate is a dimension deeply anthropological of didactics, so much that every teaching interaction is, indeed, a relationship mediated by communication (Compagno, 2025: 42-43). As a consequence, it may be proposed the notion of knowledge as the "dynamic version" of communication: if the neural connections are able to build new synaptic pathways this means that they are also established new knowledge patterns. Hence, the act to know is closely linked to eye movement. How could they contribute to learning process?

The major contribution of Rizzolatti (2006), with the discovery of "mirror neurons", gave to research the possibility to overturn traditional education practices. The peculiarity of them is that they have the same structure of other neurons but their function is working when they see others to do actions (Rivoltella, 2012 e 2024). In particular, each mirror neurons have its own functionalities such as holding neuron mirror, catching neuron mirror and so on. And how may they be activated? The mimetic activity is fostered thanks to visual perception but also to language. Its ability to abstract – creating mental schemes – come to the rescue of mirror neurons to provide a bridge between mental image and the reality building new synaptic connections and new knowledge as well. How could this be scientifically proved? It was discovered that Broca's area – language area – is now considered the core where mirror neurons develop. From this assumption, the present study claims that whether language has its own grammar code even brain has its own grammar rules. Based on this statement we may consider brain as a language code. Anyway, is it possible to give birth to a bridge in which all these elements are constituents of this axis? They have in common the objective: education. The act of imitating as a learning process may even be taken into consideration as a new teaching methodology where students imitate their teachers. In the context of the acquisition of a foreign language this neural mechanism is essential: the pathway of neurons to build synaptic connections is the same of that of language to create lexical-semantic structures. Spitzer considers learning process as the construction of new synaptic connections:

> Aprender significa modificar las intensidades sinápticas de transferencia. Dicha modificación sólo tiene lugar en las sinapsis activas. Cuanto más activo es el tejido neuro nal en una determinada área de la corteza cerebral, más cambios aparecen en las intensidades sinápticas y, con ello, más aprendizaje. (2005: 146)

To reinforce this parallelism, Rivoltella (2012, 2024) talks about "learning brain", neurobiologist say "motor brain, Craighero (2010) defines "seeing brain" and the New London Group the "reading brain". So brain has its language patterns such as phonetics, morphology, lexicon, syntax and pragmatics. With regard to this last competence, López García (2016) and Di Gesù (2017, 2019) were among the first who gave relevance to how external factors – emotion, society, environment – may affect the disciples during their acquisitional process of a foreign language. This paper has the aim to follow their way of thinking to spread it as a "nature-based education". How could be scientifically explained? The core are two components: from one hand, brain plasticity – the main cerebral property – has the capability to adapt to the context for individuals' evolutionary growth; from the other hand, the notion of autopoietic mind refers to the attribution of experience as the element which allows to brain generating meaning internal structures.

4. The *entorno* as a nature-based education for the acquisition of Spanish language

In the case of two similar languages – Spanish and Italian – their learning process needs a specific methodology to avoid linguistics bias or misunderstandings. The goal to achieve is the use of a nature-based education which could provide the right procedures to improve lexical acquisition of FL. How does nature-based education consist of? It refers to the application of an alternative approach which is "natural" without any artificial tools. Human being is the protagonist of its learning. In line with this, also teachers have to turn over their mindset in favor of an enactive approach. Moreover, it is an extension neurophenomenological[4] about the existence of a MT mental lexicon for L2 learners; thus, the intent is "blending the experience with the neurological area". Language is a social faculty which develops itself as actions inside a net of relationships (Di Gesù, 2016: 73).

It is better to distinguish between enaction and enactivism: the first term is a model related to the verb "to enact" or "the action to act in a specific context"; the second

[4] Neurophenomenology is a methodology based on the relationship between cognitive science and phenomenology. This disciple analyzes brain activity linked to personal experience (Di Gesù, 2016: 71).

one – related with the abstract conception – it has to do with the perception through action. It is a cognitive theory based on enaction (Di Gesù, 2025: 117). The founder of this notion were Humberto Marturana and Francesco Varela (1980) with the theory of autopoiesis mentioned in chapter 3. It consists on an "embodied action" where words become actions thanks to the interaction between brain and body. «Enactive model offers an innovative perspective, able to overcome borders of classical cognitive science and to propose an integrated vision of mind, body and environment» (Di Gesù, 2025: 120). How could we establish the enactive approach as nature-based in educational field? It is one of the assessment of enaction to think of knowledge connected with nature, and consequently defined as an embodied action where extra and inner factors are combined – biological, psychological and cultural context – to render education as natural as possible. López García stated:

> El hablante vive en el mundo y al hablar no hace sino re sponder a la posición que como ser vivo ocupa en relación con los demás y con el entorno. Su acción corporizada, pues de esto se trata, se dirige siempre a los oyentes, con una intencionalidad abierta a soluciones imprevisibles. (2016: 45)

The issue is, could enactive paradigm be valid for Spanish language? The employment of a minimum lexical-grammar comes to aid to build a linguistics-pragmatic competence. In this view, lexical-enactive approach may help to consolidate new words of Spanish language into a concrete context. For instance, it has been shown some of the notorious samples that in Italian are false friends, creating serious misunderstandings. The former is the Spanish word "*burro*" ("donkey" in English). It happens that when an Italian beginner listen to this word for the first time, he uses is MT as a filter and its mental scheme reconnects this word with the one closer to Italian word, the homonym "*burro*" ("butter" in English). How could the enactive approach result functionally to their learning process? Because when students learn in a specific context – i.e. classroom – teachers have to take into consideration all the external factors involved: considering how learners' emotional state may affect their linguistic production, their knowledge about the MT, the environment in which they grown and then they learn. In this specific example, one of the solutions that may be applied is that, working with a lexical-enactive approach allows disciples to know in advance in

what environment they are; with the Spanish word "*burro*" beginners have to know the lexical area such as animals and then, thanks to the teacher's guidelines, they have to elaborate a process of mental categorization. Other lexical words causing mistakes are the Spanish word "*largo*" ("long" in English); in Italian this adjective is "*lungo*" and it does not have the meaning of "large". Indeed, the paradox here, is that its formal structure is rather close to the English one than the Spanish. How could these two languages – Spanish and Italian - be so different in some case despite coming from the same family language as Latin? This is when environment comes into play: it is the application of words in a specific context which defines one meaning from another. In addition, it may also happen in syntactic terms, that – depending on the contextual use – verbs could totally change their layout: it is the case of the two Spanish verbs "*salir*" and "*disfrutar*" ("to go out" and "to enjoy" in English) but in Italian may be confused with "*salire*" and "*sfruttare*" ("to climb" and "to exploit" in English). Due to the fact that verbs represent one of the crucial grammar categories to fully understand the action of a sentence and of the whole situation (pragmatic function) this means the failure of communication. Ultimately, from a morphological point of view, two famous examples are related to the gender change from Spanish words into Italian words and vice versa; words like "map", in Spanish is "*el mapa*" instead in Italian is "*la mappa*", so from male it turns into female genre. It occurs the same with the word "flower" which in Spanish is "*la flor*" and in Italian "*il fiore*", so from female it turns into male genre. Once again, what this paper decided to label with the word "*entorno*" is a way to set the foundation of a new educational framework. Furthermore, to embrace an enactive approach from a linguistics point of view, it implies a balance between interfere and transfer already mentioned in chapter 2. The idea is to eradicate this old notion of "error" as something bad and wrong but instead as metalinguistic learning through the error analysis (Di Gesù, 2023). How should be the role of teachers assuming an enactive education? They should act as "mediators" who transfer a mental lexicon of the Italian students into their FL – Spanish language – using a task-based approach (Di Gesù, 2025: 170). The scope is that teachers have to be like "translators" who have to translate words and sentences to facilitate the comprehension for the target text, in this specific case, for Spanish disciples.

Conclusions

Nowadays the research is growing up quickly with the aim to offer a wide range of educational methodologies. The idea is reconsidering educational practices from a neuroscientific point of view helps researchers to shift from the traditional mindset focused on learners to a revolutionary one where the core is learners' brain. As Gola (2025) stated, Education contains teaching and learning studies and it is a biological and social phenomenon. The individual is, indeed, a being in relation, through different communicative process. In Gola's terms, we could use the term "Neuroumbrella" to refer to the different elements which surround the core: education; like in a circle, the first step was the theorization of Neurodidactics as a transdiscipline to find a mindset. Afterwards, the application of this "neuro" discipline to the acquisition of Spanish language. Then, in another passage it was reliable to specify the target of this present research, so beginners, showing how it is efficient the application of a lexical-enactive approach to their learning process.

Once figured out the parallelism between brain and language, it is possible to talk about a grammar of brain and a grammar of language and, on the whole, about a new people's grammar (Gola, 2025). To think on learners as a combination of linguistics codes and signs allows the spread of further research in the neuroscientific area. In this case, the implementation of a lexical-enactive approach may be a new educational model and a new way of considering language acquisition. The final object of this paper was a Neurodidactics research focused on pointing out the "*entorno*" (environment) as a nature-based education for beginner Spanish learners. In conclusion, future further research may be developed from an applicational point where beginners would be settled in a specific *entorno* (environment) within their biological and cultural background to show their consequences. Therefore, classroom – as an *entorno* – may be the new "theatre" of educational practices.

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