Cognitive Neuroscience of Foreign Language Education: Myths and Realities

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Abstract

This paper provides an overview of some educational implications from the current research on cognitive neuroscience for foreign-language learning. Although the potential benefits of such research into language acquisition are great, there are a number of popular myths none of which are supported by scientific evidence. In this paper, three prominent examples of these myths are introduced and it is discussed how they are based on misinterpretation and misapplication from neuroscience research. The first pervasive example of such misconception is the prevalent belief of being the certain critical periods for learning a second language. It implies that the opportunity to acquire foreign languages is lost forever by missing these biological windows. In fact, however, extensive research shows that there are sensitive periods, but not critical periods, during which an individual can acquire certain aspects of language with greater ease than at other times. Another example of myths is a false conviction claiming that exposing children to a foreign language too early interrupts knowledge of their first language. The reality is that learning a second language not only improves language abilities in the first language, but also positively affects students' academic performance and their general literacy in school. Like the other myths, there is also a popular misconception about ability to learn second language during sleep. It is demonstrated that previously acquired memories are consolidated and new association are acquired during sleep. It therefore does not include learning a foreign language that requires conscious effort and purposeful endeavor. The main conclusion arising from this argument is that, while our understanding of the neural bases underlying language learning is continually developing, our educational interpretation of research findings should also evolve.

Keywords: **Foreign Language Education; Cognitive Neuroscience; Neuroscientific Bases of Second language Learning; Neuromyths; Second Language learning**

Introduction

The acceleration of daily exchange of information on a worldwide scale demanded improving communication skills as a key to success in life (Koizumi, 2011). Language in this context is not only a specifically human cognitive function, but also a tool for communication and a fundamental attribute of cultural identity and empowerment (OECD, 2007; UNESCO, 2003). This has led to a longstanding interest among educators to provide scientific bases for language curriculum and teaching by

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exploring the potential contribution of cognitive neuroscience for language acquisition. Cognitive neuroscience aims to refine and explain how the human brain decodes words and sentences in native and second languages. This growing area of research potentially provides important insights needed to fine tune theories of the developmental trajectories in language learning and the acquisition of literacy (De Jong, *et al*, 2009). By understanding how the brain processes language through lifespan, native and second language educators may be better able to design more effective curricula for students in the current multilingual societies. However, there are also some misinterpreted or over - generalized claims from neuroscientific findings in regard to second language learning that have been termed as "neuromyths" (Nouri, Mehrmohammadi & Kharrazi, 2014; OECD, 2002,2007).

This paper will focus on the three instances of these myths that have been advertized mostly in public media about neuroscience of second language learning. Such an understanding is critical for foreign language teachers, foreign language learners, and educational policy makers to be aware of the implications posed by these claims. They need to be cautious and aware that some conclusions from research in neuroscience is being over-generalized and misinterpreted, and this has ethical implications.

Myth #1: It is impossible, or at least extremely difficult, to achieve competency in a foreign language after a certain age

We most often hear that it is impossible, or at least extremely difficult to learn a new language after childhood. Research on critical periods and the irreversible consequences of early sensory deprivation is often cited as evidence for the importance of early childhood experiences. The research findings have been used to suggest that there are particular times so-called "critical periods" during which certain experiences must occur to learn particular skills or abilities such as a second language effortlessly and more completely. If these experiences are absent or occur later in the course of human development, the brain will never develop properly and it will be impossible for the child ever to acquire those skills or abilities (Blakemore & Frith, 2005; OECD, 2007; Worden, Hinton & Fischer, 2011).

Reality #1: It is never too late to learn a foreign language

The term "critical period", according to Goswami (2008) implies that the opportunity to learn a particular ability is lost forever if the biological window for that ability is missed. There is evidence for limited critical periods in brain development in limited domains (such as the development of visual and motor systems in animals). No evidence, however, supports biological critical periods for acquiring non-native languages (Bruer, 1999; Worden, Hinton & Fischer, 2011).

This neuromyth rests on a static conception of the brain, which we now know to be false (Worden, Hinton & Fischer, 2011). The fact is that, our brain is plastic and capable of learning throughout the lifespan. Research on plasticity suggests that the brain is well set up for life-long learning and adaptation to the environment and that educational rehabilitation in adulthood is possible and well worth investment (Blakemore & Frith, 2005).

Plasticity, however, can be classified into two types: experience-expectant and experience-dependent. Experience-expectant plasticity describes the genetically-inclined structural modification of the brain in early life; and experience-dependent plasticity is referred to the structural modification of the brain as a result of exposure to complex environments over the lifespan (OECD, 2007). Experience-expectant plasticity,

therefore, is biologically pre-programmed and reflects abundant early growth in response to classes of environmental stimulation (such as visual field information) that the brain 'expects' (via evolution) to receive; and experience dependent plasticity is culturally constructed and includes the connections formed by all kinds of education (Goswami, 2008).

In parallel to plasticity, learning can also be described as experience-expectant or experience-dependent. Experience-expectant learning takes place when the brain encounters the relevant experience, ideally at an optimal stage of development. These periods hence should be called "sensitive periods" or "windows of opportunity", because they are the optimum moments for individuals to learn specific skills such as oral language. They are part of natural development, but experience is needed so that a change (learning) can be effective. It is not the same as "experience-dependent" learning such as vocabulary or written language, which can take place at any moment in an individual's lifetime (OECD, 2002, 2007).

Concerning foreign language learning, there are sensitive periods (the windows of learning opportunity) as language circuits are most receptive to particular experience-dependent modifications at certain stages of the individual's development. An example of sensitive periods is the time during which speech sounds are acquired. Studies show that young infants in the first few months of their lives are capable of discriminating all the sounds of the language, even those very different from the native language of their parents. For example, Japanese adults experience difficulty in telling the difference between the /r/ and /l/ sounds which are perceived as identical, but the very young Japanese baby is able to distinguish between them (OECD, 2007). Therefore, there appears to be a sensitive period for learning phonology, with evidence that infants are initially able to recognize and distinguish phonemes across multiple languages, but after three to six months of age and exposure to the sounds of the languages spoken at home, children become more skilled at producing the sounds that appear in languages that they have heard (Worden, Hinton & Fischer, 2011). An important reason why it is preferable to denote this aspect of human learning in terms of "sensitive" rather than "critical" periods is that it refers to a loss not an increase in information (OECD, 2007). This effect appears to be the result of neural pruning (removing less efficient neural connections), that probably increase the efficiency of sound processing by the brain (Worden, Hinton & Fischer, 2011). There is also a developmental sensitivity during which learning the grammar of a language can be achieved more fluently in young children than in adults. In other words, the earlier a language is learned, the more efficiently the brain can master its grammar (OECD, 2002). If the brain is exposed to a foreign language between 1 and 3 years of age, grammar is processed by the left hemisphere as in a native speaker but even delaying learning until between 4 and 6 years of age means that the brain processes grammatical information with both hemispheres. When the initial exposure occurs at the ages of 11, 12 or 13 years, corresponding to the early stage of secondary schooling, brain imaging studies reveal an aberrant activation pattern. Delaying exposure to language, therefore, leads the brain to use a different strategy for processing grammar. This is consistent with behavioral findings that later exposure to a second language results in significant deficits in grammatical processing (OECD, 2002, 2007). Early exposure to grammar thus leads to a highly effective processing strategy, in contrast with alternative and less efficient processing strategies associated with later exposure (OECD, 2007).

In addition, there is a sensitive period for acquiring the accent of a foreign language. This aspect of phonological processing is most effectively learned before 12 years of age (OECD, 2007).This explains why children who have learned a second language during early years of their development are able to produce it with an accent typical of their primary language (Flege, 1993).

In sum, there is an inverse relationship between age and the effectiveness of learning many aspects of language. Thus, the earlier the child is exposed to the language, the easier and faster the grammar is mastered. Semantic learning, however, can and does continue throughout the life span and is not constrained in time (OECD, 2002, 2007). Furthermore, the long history of research in cognitive psychology have shown that rate and ease of learning depends more on prior background knowledge than on chronological age (Bruer, 2002).

Although the early learning of language is most efficient and effective, it is possible to learn language throughout the lifespan. That means adolescents and adults can also learn a foreign language, albeit with greater difficulty. Indeed, if they are immersed in a new language environment, they can learn the language "very well", though particular aspects, such as accent may never develop as completely as they would have done if the language had been learned earlier (OECD, 2007). Efficiency and mastery are not necessarily lost, but are just more difficult for the late learner, because relevant experience has not been received within a biologically defined time frame (OECD, 2002). There are also individual differences such that the degree and duration of developmental sensitivities vary from one individual to the next. Some individuals are able to master almost all aspects of a foreign language into adulthood, and some individuals can still acquire close to a native accent in adulthood (OECD, 2007; Worden, Hinton & Fischer, 2011). Recent studies have shown that adult non-native language learners are actually quicker at acquiring new vocabulary in a second language and that they may draw on a sophisticated understanding of meanings that gives them advantages over young children. Recent studies have even begun exploring the cognitive benefits of acquiring a non-native language in adulthood for mitigating or delaying the symptoms of some age related disorders such as Alzheimer's (Worden, Hinton & Fischer, 2011). Furthermore, for a foreigner speaking in a given language, the benefit of acquiring a "native speaker accent" is not clear anyway (OECD, 2007).

On the practical level, the one main conclusion of the research findings in this area is that learning a second language after 13 years of age is extremely likely to result in poor mastery of the grammar and accent of this language. This result is at odds with the education practices in numerous countries where second language learning starts approximately in sixth or seventh grade (OECD, 2002, 2007).

Myth #2: Exposing children to a foreign language interrupts knowledge of their first language.

According to this misconception, different languages are localized in the same areas of the brain. Introduction of a foreign or second language while the child was still learning the first might interrupt language development or cause the child a confusion of language sand it is the best to speak to child in native language until high school (Frey & Fisher, 2013; Petitto, 2009; OECD, 2007). In other words, the more one learns a new language, the more one necessarily loses the other. From these ideas, it has been supposed that the simultaneous learning of two languages during infancy would create a mixture of the two

languages in the brain and slow down the development of the child. The false inference is that the native language had to be learned "correctly" before beginning another one (OECD, 2007).

Reality #2: Learning foreign languages helps foster other competences related to language.

One of the research lines in the cognitive neuroscience of second language learning is to examine the impact of first language learning on second language learning. Although children are generally considered to acquire fluency in languages easily and educators are highly aware that students are having great difficulty in learning second languages later in the school years, paradoxically, some educational systems hold that exposure to a foreign language education too early will impede progress in native language (De Jong, *et al*, 2009; Petitto, 2009).

This claim is not supported by what we know from scientific studies. This myth arise from the studies conducted at the beginning of the 20th century, which found that bilingual individuals had inferior "intelligence", were carried out with faulty methodologies, being based mainly on migrant children who were often undernourished and in difficult cultural and social conditions. The protocols should have taken into account that many of these children had started learning the language of their host country around the age of 5, 6, or later, and, without a strong command of that language, they had problems learning other subjects. In short, we cannot meaningfully compare the intelligence of monolingual children from native, often well-off families with that of multilingual children from primarily underprivileged environments with limited family knowledge of the dominant language (OECD, 2007).

Recent studies have revealed overlapping language areas in the brain of people who have a strong command of more than one language. Experiments have found that the more knowledge is acquired in different languages, the more it is stored in areas far away from the area reserved for language (OECD, 2007).For instance, fMRI studies have shown that native and second languages in early bilingual subjects tend to be represented in common frontal cortical areas (Kim, Relkin, Lee & Hirsch, 1997). Other studies using fNIRS shows robust activations in the brain's classic language areas and the same recruitment of language -dedicated neural tissue in bilingual and monolingual infants. This is also demonstrated that bilingual children should not experience difficulty with phonological word segmentation in two languages and they show an increased sensitivity to a greater range of phonetic contrasts, and an extended developmental window of sensitivity for perceiving these phonetic contrasts than monolingual children (see Petitto, 2009).

Behavioral evidence also validates the *positive* effects of second language learning on multiple aspects of child development (Demont, 2001; OECD, 2007; Petitto, 2009). Indeed, children who experience *early*, *extensive*, and *systematic* exposure to both of their languages do not get weaker in their first language, but instead quickly grasp the fundamentals of both of their languages (Petitto, 2009).More particularly, the results showed an advantage for the children who attended bilingual classes since kindergarten. These children will gain access to the written language with more ease and they are better at grammatical judgment and correction tasks and word recognition (Demont, 2001).Bilingual infants are able to discern the differences in the phonemes of both languages and are sensitive to a wider range of phonemes than monolingual babies (Norton, Baker, & Petitto, 2003). In addition, there is also evidence in supporting the positive effects of bilingualism not only on language

abilities, but also on mathematical processing and general learning in school (Geake, 2009).These positive effects are clearest when the second language is acquired early; a multilingual education does not lead to a delay in development (OECD, 2007).

Taken together, the myth that one has first to speak well one's native language before learning a second language is counteracted by the studies showing that children who master two languages understand the structure of each language better and apply them in a more conscious way (OECD, 2007).

Myth #3: It is possible to learn a second language while sleeping.

There is a long history of research speaking to the importance of sleep as the primary source of learning throughout lifespan. Like the other myths, popular conceptions about ability to learn second language during sleep come from misinterpretations of legitimate neuroscientific findings. Research on the role of sleep in memory functions, especially to memory consolidation (see Peigneux, Laureys, Delbeuck & Maquet, 2001) is often cited as evidence in support of this idea that foreign language learners are able to learn English (or another foreign language) during sleep. Commercial products promise phenomenal success, claiming that learning while sleeping is not only possible, but even is more efficient than while awake. The idea suggested that the act of learning always begins with an unconscious process and so it is more efficiently done during sleep than while awake (OECD, 2007).

Reality #3: Learning a foreign language requires conscious effort.

There is compelling evidence that sleep plays significant function in the development of the brain and memory. There is a considerable body of literature suggesting that information acquired during waking can be reactivated during sleep (Antony, *et al*., 2012). There are studies endorsing that some individuals are capable of problem solving while they sleep. According to these studies, it is the old problems can be consolidated during sleep or hypnosis in unconsciousness states not novel (never before experienced) information (Tokuhama-Espinosa, 2010). In a more recent study, Arzi, *et al*., (2012) demonstrated that people can also learn a new association during sleep without later awareness of the learning process. According to the results of this study, sleeping participants were able to form a link between a particular tone and a pleasant or unpleasant smell. Although this study demonstrated that it is possible to acquire a simple association while fast asleep, learning more complex skills, such as learning a new language, may still not be possible during sleep. Language learning not only entails consciously memorizing dozens of new words and their meaning, but also entails to develop a learning strategy and continuously restructure the newly acquired information in a fashion coherent with the preexisting knowledge base (Peigneux, Laureys, Delbeuck & Maquet, 2001).

At present, one paradigmatic implication of research findings along these lines is to manage the time between teaching and learning phases (Blakemore & Frith, 2005). However, no scientific evidence supports strong claims about learning while asleep and whether sleeping or not, one cannot rely on simple repetition for learning. To learn a foreign language, natural sciences, physics, etc., conscious effort and purposeful endeavor is required. In conclusion, the CDs to be played while asleep promise a pathway to better learning, stopping smoking, and losing weight (among many other things), but there is no scientific evidence to support these promises.

Maybe it is not the CD that makes you stop smoking or lose weight, but motivation. Learning while asleep thus continues to be a myth and it is highly unlikely to see such approaches as one day recommended parts of school or university curricula (OECD, 2007).

Conclusion

In a world where globalization and migration patterns have meant a dramatic increase in the number of non-native language learners who enter school each year and need to learn more than one language, bilingualism and multilingualism are becoming the expectation instead of the exception (Worden, Hinton & Fischer, 2011) and it is more a way of life than a problem to be solved (UNESCO, 2003). It is, therefore, need to take into account how the brain processes language in order to promote students' language acquisition, but based on evidence, not neuromyths (Worden, Hinton & Fischer, 2011).

It could be argued that the prevalence of neuromyths has a major influence on shaping the perceptions and practice of teachers and curriculum planners who have responsibility to educate our children. The main conclusion arising from this argument is that our understanding of the neural bases of second language learning is continually evolving. It implies that our interpretation of the implications of these findings for teaching and learning should also continually evolve. It is, therefore, crucial to be cautious in translating basic scientific research into educational policy and practice.

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