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**COCHLEAR IMPLANTS
AND SECOND LANGUAGE ACQUISITION**

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ABSTRACT

This Final Degree Paper analyses different cases of people with a hearing deficit receiving cochlear implants, present in the Aronson & Co's 2000 documentary *Sound and Fury*, and it explains how differences in the age of implantation and in the quality of the input received affects the performance and level of proficiency of the cochlear implanted patients. The study explores deafness not as cognitive but as a sensorial deficit, and establishes similarities between the implanted patients and their comprehension and production of spoken language as an L2 or as a FL. As the Applied Linguistics' project it is, this study uses linguistics', medical and second language acquisition knowledge and applies it to address the challenge the integration of deaf speakers into the mainstream community of speakers entails for society. This study will answer questions such as: "Can the deaf people speak?", "At which age can cochlear implants be more beneficial for them?", "Should they be taught sign language, if implanted?", "Why do they speak in a way resembling a foreign accent?", "Which are the factors that trigger the differences in the oral comprehension and performance between the different patients?" and most important of all, "What is the best way to help them?".

Key Words: deafness, cochlear implants, second language acquisition, foreign language learning.

RESUM

Aquest Treball Final de Grau analitza diversos casos presents al documental d'Aronson i Companyia *So i fúria* (2000) de persones amb dificultats auditives que reben implants coclears, i explica com diferències en l'edat d'implantació i en la qualitat de l'exposició lingüística afecta el nivell d'execució i de domini de la llengua dels pacients. L'estudi explora la sordesa no com un dèficit cognitiu sinó sensorial, i estableix semblances entre els pacients i la seva comprensió i producció de la llengua oral com a llengua 2 o com a llengua estrangera. Com a projecte de lingüística aplicada que és, aquest estudi utilitza coneixements tant de lingüística, com de medicina i d'adquisició d'una segona llengua per resoldre el repte que la integració de persones amb dèficit auditiu a la comunitat de parlants representa per a la societat. L'estudi respondrà qüestions com: "¿Poden els sords parlar?", "¿A quina edat és la implantació coclear més útil per els pacients?" "¿Se'ls hi hauria d'ensenyar llenguatge de signes, encara que rebin l'implant?", "¿Per què tenen una parla semblant a una llengua estrangera?", "¿Quins son els factors que desencadenen les diferències al entre nivell de comprensió i producció oral dels diferents pacients?" i, el més important: "¿Quina és la millor manera d'ajudar-los?"

Paraules clau: Sordesa, implants coclears, adquisició de la segona llengua, aprenentatge d'una llengua estrangera.

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1. INTRODUCTION

This final degree paper addresses the sensorial deficit of deafness from an Applied Linguistics perspective, exploring the solution of cochlear implants and the factors of access to a natural language, age of implantation and teaching methodology which will determine the patients' first language acquisition, second language acquisition, and foreign language learning of the oral English language. First invented in the 1950s, cochlear implants are electronic devices that replace the natural human cochlea, transforming the sound signal received by deaf patients into an electronic one sent into their brain, allowing them to relate each signal with a given object by means of pair association between the signal and the object. Despite these pair associations being different from the analogical input of a natural cochlea, they achieve the same human communicative purpose.

When people are young it seems easier for them to acquire a language. One possible explanation for this is the behavioral view that cochlear implanted patients implanted at adulthood have fixated previous connections which, as argued by Hermas et al. (1998) in Kormos (2006), become simultaneously "activated and compete for selection" (p.64) with the new associations given to an object, interfering with the new sets of words and sounds; deaf patients have created their own "phonetic categories" (Schovel, 1998, p.54) from the distorted muted signals received and gradually internalized during the years of life, selecting those over the new categories, not yet acquired as a skill. Another way to explain it is from a biological determinist approach, according to which children from 0 to 6 years old are in a "critical period for second-language acquisition" (Vanhove, 2013, p.1) which "coincides with the process of lateralization of the brain" (p.1), in which the organ has more plasticity, and language can be more easily acquired in terms of sounds.

Be there a critical period for the acquisition of sounds or not, deaf children seem to have created and fixated their own, smaller set of "phonetic categories from the distorted muted signal received through the years" as claimed by Schovel (1998, p.54). Therefore, the latter they undergo the cochlear implant surgery, the more muted pronunciation they will produce, similar to the foreign accent non-deaf foreign language learners have. Adult implanted patients seem to respond better to explicit grammatical teaching of the L2 declarative rules in order to comprehend the language before being able to produce speech in that language, as Kormos explains in her L2 production model, a revision of Level's L1 production system (Kormos, 2006, p.150-162). Biological determinists will attribute this to a Critical Period for SLA of higher brain plasticity comprised between 0 and 6 years old, related to a process of lateralization of the brain, while social behaviorists argue in favor of a Linguistic Interference taking place after the automatization of the previous L1 rules at an age in which acquisition is easier because linguistic interference does not yet take place. In both cases, it seems there is a behavioral component to it, since the quality of the input received is also a key factor to foresee whether the subject is going to acquire or learn English as an L2, and to which degree of proficiency, both in comprehension and production. Younger adults seem to benefit more from L2

acquisition by following a communicative learning approach, whereas rules must be explicitly taught for elder late learners.

The linguistic challenges deaf patients must face after receiving the cochlear implant in order to master the English language orally parallel those of hearing students acquiring oral English as a first, second or learning it as a foreign language. Even the same ones as hearing feral children, who, biologically-deterministically speaking, could not acquire a natural language at the “auditory critical period” (Vanhove, 2013, p.1) that comes “from 0 to 6 years old” (2013, p.1) of “brain lateralization and higher brain plasticity” (p.1) or, following a more behaviorist approach, did not have access to the right language input; another problem that deaf patients have to address is that of their foreign pronunciation, increasing with the age of implantation. The behaviorist approach argues that, although lower phonetic interference takes place from sign language signers learning an oral language than from an oral speaker learning another spoken language, there still is from the residual muted signal received in the critical years for SLA –or in those in which linguistic interference is less present-, which will have become fossilized as “an acquired skill” according to DeKeyser (2007, p.4-223) and which will be activated by the brain over the new selected words and sounds, still “declarative knowledge” (2007, p.4-223), waiting to become “procedural”, “automatized” and “acquired skill” (p.4-223).

Although biological determinists argue acquisition can only take place in early ages, when the brain plasticity of the subject is higher, especially with sound acquisition, evidence points at LA as simply being easier at early ages, being combination of the human natural “Categorical Perception” (In Schovel, 1998, p.54) or capacity to categorize sounds into discrete categories, and the training of it in a given language through practice, both being a combination of nature and nurture. Learning a language after a cochlear implant is close to learning language as a second language or as a foreign language, and acquiring oral language as an L2 in the cases of deaf signers implanted in their first years of live, before the critical period for language acquisition takes place, or before automatization and fixation of L1 sounds and rules triggers language interference with the L2, depending on the approach we trust.

The reasons for the choice of the topic of cochlear implants and second language acquisition for this dissertation paper are many. To begin with, it will be useful for us to understand, as teaching educators, what is the best methodology for each student to learn in class, and how we should take into consideration the students’ age of exposure to the language, and their linguistic background before choosing a communicative language teaching approach over a more traditional and explicit teaching one, or the other way around. It also serves the purpose of integrating students with special needs, -especially hearing deficit patients with a cochlear implant and newcomers who do not yet know the local language of instruction-, so as to embrace diversity into the second/foreign language classroom.

In order for this final degree paper to reach its aim, the following methodology is followed: Section 2 will provide a historical overview of deafness and on how Applied Linguistics' discoveries have helped people make decisions to improve their integration into the hearing world, providing tips and technology to allow their access to the language of the hearing community. Next, a section on L1 deprivation will help people understand the sensorial nature of the deafness deficit, disclosing the lack of exposure to a natural language as the real cause of possible deaf people's cognitive delays, argued as proof of the existence of a Critical Period for language acquisition by some, and as fixation of the non-discrete jungle sounds by others. Next, Section 5 will comment on the sociolinguistic problematic of deafness, and the struggles that deaf implanted patients living in sign communities must face, using the implants to bridge the gap between the hearing and the speaking worlds. Section 5 will analyze the age of implantation factor in the learning of oral language or of English as an L2 undergone by Heather, a girl implanted at the age of 9 years old, as well as the best teaching methodologies and main problems she will have to face. Section 6 focuses on the importance of the input factor and on the Communicative Teaching approach for Children's SLA, which will determine either their acquisition or learning of oral English as an L2. This will be achieved through the comparison of Nancy and Shelby, both implanted at the age of 1 but with entirely opposite learning methods and type of language input received. Next, section 7 will address a case in which explicit teaching is preferred over the communicative one at the beginning, and that is the case of adult foreign language learners who, as Nita implanted at the age of 50, receive the cochlear implant late. Finally, this final degree paper analyzes statistical evidence for the Critical Period Hypothesis and that supporting the Language Interference one, in order to explain the differences in ultimate language mastery between the different cochlear implanted patients. Conclusions will address the findings of this work.

2. DEAFNESS: HISTORICAL OVERVIEW

“We all should grab the opportunity to bridge the worlds within your own lives”

(Heather in TED Talks, *Heather's World*, 2013)

Unable to communicate with a dominant speaking world which does not foster the teaching of sign language at schools, children with a high hearing deficit born from deaf parents have been often confined to local deaf people communities, where they can find job opportunities at the cost of being isolated from the speaking world. A fate shared by a minority of extreme cases of deaf children that, born in speaking communities, had been marginalized or ostracized by parents who, in the worst case, confined their offspring to the house's basement into a deeper isolation, so as to hide what was generally wrongly believed to be the chronically mental disorder of their children.

The advent of Applied Linguistics began to address the difficulties of these children, trying to see what the problem really was and to come up with solutions to improve the understanding of deafness, the improvement of deaf people's communication and their integration into society. In 1950,

Chomsky's generativist theory of the "Universal Grammar" (In Schovel, 1998 p.54), empirically related to medical discoveries of brain plasticity, explained why Victor, the child in François Truffaut's film *The Wild Child* (1970) suffered not a chronic or natural mental deficit from the moment of his birth, but the cognitive delay result of not having been exposed to any language "nurturing" his categorical perception (Schovel, 1998, p. 54) at what for biological determinists was the Critical Period for language acquisition. For behaviorists, the CP comprises the early ages in which acquisition is easier due to the lower presence of linguistic interference. This is the case of DeKeyser (2007), who would attribute the cognitive delay to "a lack of practice and automatization" (p.4-323), combined with the fixing of the feral children's jungle sounds, which are not discrete as human language, but continuous, to which the child would have accustomed his brain.

Although feral children have been often used as evidence for the existence of a Critical Period of SLA due to their later difficulties in acquiring a new language, the behavioral view to explain their problems is also possible. In both cases, however, it is paramount for exposure to at least one natural language to take place at an early age, since it guarantees the learning of a natural language within a lifetime span, preventing this cognitive delay. As children who were born deaf were displaced from the dominant speaking world, deaf communities of speakers were created so that the pidgins they used for communication became fully operative sign languages, later recognized by linguists to be natural languages, their complexity being equal to their oral language counterparts. Even though no longer speaking parents considered their deaf children to have a mental disability, for a long time these were sent to sign language schools and into those deaf communities, where they were provided with more work opportunities.

Even though deafness was finally universally recognized as a sensorial rather than a cognitive deficit by linguists, there was a communicative gap between the emergent signers' community and the speaking dominant one, since deaf people being a minority; governments did not foster linguistic policies that taught speaking children any sign language. Unable to communicate with their speaking counterparts due to their incapacity to hear the language they wanted to learn, deaf people had to live in communities, and attend special schools where sign language was taught. This, together with a general misinformation about the condition of deafness amongst the speaking communities, made this gap bigger, as speaking children ostracized or bullied deaf ones, "for fear, ignorance or incapability to understand what deafness really was", as Heather Argues (Heather in *Heather's World*, 2013). A rivalry was created between the speaker community, who often considered it superior for being the dominant culture, and the emergent deaf one, who grew a pride to counter the marginalization suffered by speakers whom, incapable of understanding the deaf people's problems, kept them apart.

It was in the 1970s, however, with the discovery of cochlear implantation surgery by that deaf children were given the chance to become part of the speaking communities. For the first time ever, deaf born patients could be able to nullify the sensorial deficit of hearing by receiving a cochlear implant to replace their impaired natural sensor, sending auditory signals to their brains, and bring to

children born deaf the capacity to hear, and with it, the necessary access to oral language input, so that those children can have the means to access oral language input so that they can later produce oral language. The differences in the progress and success of cochlear implanted patients to either learn or acquire oral English language, however, depends on both biological capacities and sociolinguistic factors.

The main determinants are the age of cochlear implantation and the quantity and quality of the oral language input received, as it will be stated. Speech therapy works in some cases to ease articulatory productive difficulties of those speakers implanted at an age later than that of the natural age for language acquisition for some or than that of lower linguistic interference to others. This paper explains the condition of deafness and the differences and similarities present in each of the analyzed individuals' speech. By focusing on the analysis of deaf cochlear implanted patients coming from different linguistic environments and learning speaking languages at different ages, parallelisms will be established between their difficulties in pronouncing and learning the oral English language and the difficulties native speakers of an L1 have in understanding and producing the sounds of a first, second and of a foreign language.

3. L1 DEPRIVATION: THE REAL CAUSE BEHIND COGNITIVE DELAY

The sentence uttered by Heather (2013) in Ted Talks, “sometimes people can be mean, but not because they are cruel, because they don't understand” raises awareness on the lack of information people have about deafness, its causes and its effects in language comprehension and production. Deaf children born of speaking parents were misunderstood, ostracized from society and even sent to mental asylums; under the misconception that deafness was a mental deficit, rather than the sensorial one it actually is. The isolation of deaf children resulted in more marginalization and in their lack of access to a natural language during infancy, -their critical period of language acquisition (Chomsky, 1950, p.8), for some; earlier ages of lower language fixation and interference to others-, which were the real causes behind their subsequent cognitive delay. A cognitive delay which would have been prevented had they been taught sign language by their relatives or had they had access to the cochlear implants in their first years of life, so that oral English communicative native language input could have reached their brain at the right time for L1 acquisition. According to some linguists, acquisition is a process which takes place naturally, and which “provides children with the cognitive tools to processing thought through language”, as the linguistic relativist Sapir-Whorf hypothesis defends (Whorf, 1940, p. 230). The real case of Victor, a feral child appearing in *Truffaut's The Wild Child* (1970) documentary will illustrate an example of L1 deprivation and the cognitive delay it entails, applicable to the cognitive

delays of deaf children whose parents' oral language input couldn't reach their ears before cochlear implantation was first invented.

3.1. Feral Children and first language acquisition: Victor's case in Truffaut's *The Wild Child* (1970)

Deafness is a sensorial deficit produced by either congenital causes –due to its being a hereditary condition or to the suffering of some genetic mutation- or by acquired causes –a later illness or trauma. According to Noam Chomsky (1950, p.8) and those linguists that follow a generativist perspective, “all children are born with the Universal Grammar innate capacity to acquire language” (in Schovel, 1998, p.13). However, in order for children to speak a language, they must be able to comprehend it first by nurturing their given Universal Grammar Capacities. As argued by Schovel (1998 p.54), children understand sounds through their “categorical perception”, or their natural capacity to classify “the continuum” of sound signals into “arbitrary categories, influenced by the linguistic environment a child is raised in” (p.54).

This means that word pairs such as [Ben] and [pen] are only differentiated by the “length of time it takes between the initial puff of air that begins these sounds and the onset of voicing in the throat that initiates the following vowel” (Schovel, 1998, p. 54), which ranges between 50 milliseconds. In Schovel's psycholinguistic experiments conducted, when hearers were given an exact intermediate sound between the two sounds they still automatically categorized what they heard into either [b] or [p], proving Schovel's affirmation: “when a language learner is exposed to the VOT settings of a particular language over an extended period of time, they use their innate capacity to perceive sounds categorically to acquire the appropriate phonetic sound settings” (p.55).

According to one of the most widely-accepted linguistic theories at the moment, words are comprehended thanks to the nurture of the Universal Grammar's “Parallel Distributed Processing” (Schovel, 1998, p.55) or the human capacity to activate a series of “logogens” (p.56), lexical devices which categorize words according to their spelling, pronunciation, grammatical functions and the “spreading activation networks” (p.56) of associations of each word's meaning. The “Tip of the Tongue” phenomenon empirically demonstrates how, a word is often recalled by its first letters or by any associative clue (p.57). Finally, sentences are comprehended according to the “garden-pathing theory” (p.65) or the predictions about the meaning of a sentence as it progresses, meaning there are some formulaic semantics at work.

The example of Victor in Truffaut's *The Wild Child* (1970) serves to illustrate what happened to deaf children born from speaking parents before the 1950s: when their parents did not take them to private schools to acquire sign language, they were not exposed to any natural language at an early age, which is when it is easier –by reasons of a higher brain plasticity and a lower linguistic interference- to acquire a language. Higher brain plasticity and/or the absence of L1 interference allows children to create phrasal, lexical and especially phonetic categories for the specific language

input received. When no fluent language input from a natural language, be it sign or oral, can reach the children at the right early age for language acquisition, these environmental factors alone will trigger the cognitive delay that makes people process linguistic information slower and with more difficulty, and not the condition of deafness per se or any biologically-conditioned mental disorder.

According to the Sapir-Whorf hypothesis, “language determines thought” (Whorf, 1940, p. 230), reason why we know children like Victor, who was self-brought up in the jungle without any interaction with other human beings, could not fully develop their cognitive skills during their first years of age – the critical period of language acquisition for some, the one free of Linguistic Interference to others-. Feral children like Victor were isolated from the necessary language 1 input to nurture the creation of right “phonetic categories” (Schovel, 1998, p.56) to distinguish sounds, “spreading activation networks of logogens” (p.58) to understand words and “garden paths” for sentence semantic processing” (p.65). Even though Victor learns by his master’s instruction to recognize, understand the meaning of, and even produce some words and sounds, he will always suffer of a significant cognitive delay, reason often used to support the Critical Period Hypothesis. However, his cognitive delay can be also due to the fossilization of L1 phonetic or linguistic categories misheard and therefore misunderstood during their previous hearing deficit years, when continuous rather than discrete sounds reached the feral children’s ear, not nurturing the brain’s capacity to classify sounds into discrete categories.

Lantos in Mellon (2015), an expert otolaryngologist, conducted an experiment on the effectiveness of cochlear implants, in which patients implanted earlier, performed better in all language levels, especially in phonetics. He reaches the following conclusions: “Pre-lingual children under 6 years of age should receive a cochlear implant as soon as there is a reliable diagnosis of bilateral sensorineural loss” (p.174). It is paramount that deaf children are taught sign language as soon as diagnosed, so that they can have access to a natural language and develop the necessary cognitive skills that the acquisition of a natural language provides, including a more trained use of working memory and the skill to produce and understand language and thought, by encoding and decoding verbal messages. As a matter of fact, deafness only entails a physical cognitive deficit when it is caused by an added trauma or genetic alteration that affects a given area in the brain. In the same way, it only provokes a cognitive delay when deaf children of speaking parents do not get their deafness sensorial deficit diagnosed early, and therefore do not get exposed to a natural sign language such as the American sign language when it is easier for them to acquire the given oral language. This is why an early diagnostic is so paramount, to prevent the cognitive delay that Victor suffers in his deprivation from language, as we know that he was self-raised in the jungle past his childhood, suffering the mentioned cognitive delay as his difficulty to cope with complex linguistic tasks such as comprehension and production of complex sentences shows.

What Applied Linguistics teaches us through the example of Victor is that all children should always receive an L1 input, be it oral or sign language, in order to allow the full development of their

cognitive capacities. Whereas speaking children of deaf parents could still have access to native sign language input, deaf children born of speaking parents should be taught sign language immediately, even if they receive a cochlear implant soon.

4. COCHLEAR IMPLANTS: SOLVING THE DEAFS' SENSORIAL DEFICIT

The advent of cochlear implant surgery in 1970 changed the lives of children deaf for congenital causes, incapable of hearing the dominant language of the speaking communities. Unable to communicate orally, they could not integrate outside deaf communities, where their original pidgin signs had evolved into complex language systems and a huge variety of sign languages spoken now around the globe. Pressured by their deaf families' pride, by the lack of attention placed by the governments to teach all children sign language, by the insensibility of speaking children shown towards deaf children's particular speech, by the still prevalent ostracizing misconception of deafness as a cognitive deficit, and by their inability to access the spoken language due to their sensorial deficit, deaf people were quite comfortable in their own communities, separated from the speaking world by an apparently unbridgeable gap.

4.1. Bridging the gap between the speaking and signing worlds. Aronson & Co's (2000) *Sound and Fury* documentary

However, it was when cochlear implantation was possible that children such as Heather could decide they wanted to hear, so that they would ask for a cochlear implant in order to be able to attend the University and communicate with the speaking world. In Ted's Talk *Heather's World*, Heather (2013), the daughter of deaf signing parents implanted at the age of 9, speaks about the need of "grabbing the opportunity" that cochlear implantation brings to children born from the 1970s onwards. She talks of the need "to bridge the worlds within your own lives" (2013), meaning of being able to take place and belong to both the speaking and the deaf communities. Despite the skepticism of biological determinist doctors about her possibilities for progress, Heather's cognitive mastery of the sign language, as well as her explicit speech therapy and integration into a speaking children school after receiving the implants, finally allows her to master the oral language quite proficiently, yet facing the same errors that foreign language learners must cope with, especially in pronunciation, which despite it not being that of a native speaker, becomes quite communicatively-efficient.

Heather's case of a child who decides to receive cochlear implants is not the only one disclosed in Aronson & Co's (2000) *Sound and Fury* documentary. The film features the case of Nancy –daughter of deaf signing parents, and implanted at the age of 1-, Shelby –daughter of speaking parents implanted at the age of 1-, Heather –daughter of deaf signing parents, implanted at 9-, and Nita (daughter of deaf parents, implanted at the age of 50). Their cases will be analyzed in-depth so that an Applied Linguistics' explanation can be provided about their similarities and differences in their

individual understanding and production of oral English language, time after the cochlear implantations begin.

5. MUTED SPEECH AND IMPLANTED CHILD L2 LEARNERS

In *Heather's World*, Ted Talk, Heather (2013) stated: "People ask me where am I from, because they don't understand the reason of my foreign accent". Another key factor for language proficiency in deaf cochlear implanted patients is the age of implantation, since later implanted patients will have a set of previously-created "phonetic categories" (Schovel, 1998, p.54) that will compete for selection as "declarative knowledge" with the ones De Keyser would have said to have already fossilized and become "a skill" (2007, p.4-323), being easier for the brain to select similar sounds from the muted phonetic categories created at an early age, either before L1 fossilization took too much place, negatively conditioning L2 acquisition, or during the hypothetical Critical Period for language acquisition of Brain Plasticity (from 0 to 6 years) in which neurons expand more rapidly. Be it as it might, in all cases the higher exposure to reduced and distorted hearing sounds heard before cochlear implantation, results in a foreign-like speech of the adolescent foreign language learner, deaf or not.

5.1. The Age Factor. Adolescents and L2/FL learning. Heather's case from Aronson's *Sound and Fury* (2000), implanted at 9

Aside from receiving the cochlear implants and being exposed to a natural language at an early age, -call it critical period of language acquisition or period of lower language interference-, to develop the necessary cognitive skills for language processing and production, time of implantation will be a key factor when it comes to the deaf implanted patients' success in speaking and understanding the oral language, especially in terms of pronunciation. The age of cochlear implantation will determine whether the implanted person is going to acquire or to learn the oral language.

Implanted and allowed to hear for the first time in her life at the age of 9, past the age of lower language interference for some or the critical period of higher brain plasticity for language acquisition to others, Heather will not be able to acquire oral English as an L2, but she will learn the language by receiving input from her classmates at a standard speaking school, and from the native oral English input received from her grandmother. Her case provides some evidence for the Critical Period for language acquisition from 0 to 6 years old regarding brain auditory plasticity for the categorization of sounds. However, it poses especial proof for the "Language Interference Hypothesis" (Colomé, 2001) according to which Schovel's "categorical perception" (p.54) is nurtured through practice, which turns what DeKeyser (2007) argues is the "declarative knowledge" into an "acquired skill" (p.4-323). The skill seems to be more easily acquired during the first years of life, when L1 interference does not take place as much, than during the adults' post-implanted period, when learners will have activated

phonetic interference from the previous phonetic categories acquired before the cochlear implantation took place, and fixated for a higher period of time, making the brain select the former over the latter activated “phonetic categories” (p.54) of the correct oral English language system.

Heather’s case also provides some evidence to explain the differences between the acquisition of an L1 and the learning of a FL or an L2, as illustrated by Kormos’ modular production theory (2006, p.150-162), which establishes explicit declarative rules as necessary for the formulator’s module of speech production to be able to make the morpho-phonological encoding –the ordering and selection of sounds-, a process not necessary for language acquirers at early age, who automatically establish the right phonetic categories in an unconscious automatic and natural way (See Fig.1), or by a method less affected by language 1 interference. Heather’s case will show how morphology, syntax and grammar are easier to be learnt at later ages than pronunciation, due to the fixation of the phonetic categories naturally created by Heather’s pre-implant limited and muted sound input, which have been acquired and established in her brain ever since she was born up until the age of 9.

According to Poulisse (1999) in Kormos (2006, p.84), tongue slips prove how “concepts in L1 and L2 can erroneously activate both language lemmas”, resulting in slips in the tongue where Ditch L1 Speakers selected L1 Dutch lexemes in place of L2 English ones because L1 lexemes were more frequently used. Something similar occurs with sounds. Robert De Keyser (2007) explains how “declarative knowledge” > “procedural” > “automatized” directly in L1 acquisition > “an acquired skill.” (2007, p.4-323). This is why it is easier for a 9-year-old children’s brain learning a foreign language to choose a similar already acquired L1 “phonetic category” (Schovel, 1998, p.54) from the brain database than to select a new phonetic category learnt artificially past the hypothetical “Critical Period for Auditory Plasticity” (Manrique, 1999, p.193) and an early age in which there is lower phonetic Language Interference, easing language acquisition. This way, speakers can more easily avoid to continuously apply the former L1 categories into the L2, creating fossilized errors. It is not until Heather receives speech therapy –or declarative L2 rules and explicit language teaching- or specific phonological training to create new phonetic categories, especially those related to consonants and nasal sounds, un-perceived by the distorted pre-implant oral language input-, that she manages to little by little turn the new FL phonetic and phonological declarative rules into automatized knowledge and into a skill that she will little by little achieve an understandable pronunciation, although almost never a native one. See 21-year-old Heather’s oral pronunciation when compared to a native speakers’ one:

SENTENCE: “We all should grab the opportunity to bridge the worlds within your own lives”
 NATIVE ORAL ENGLISH: /wi: 'ɔ:l fʊd' græb ðə ɒpə 'tju:nɪti tə 'brɪdʒ ðə 'wɜ:rlɪdz wɪ 'ðɪm jər 'əʊn 'laɪf/
 HEATHER’S PROD.: “/bwi: 'æb fʊd' græb də ɒpə 'tju:nɪti tə 'brɪtʃ də 'wɜ:tz wɪθ jəb 'əʊb 'laɪbs/”

(Heather in Ted, *Heather’s World*, 2013)

Despite the particularities of deaf people's muted pronunciation, with errors, especially in the differentiation and articulation of voiced consonants, the difficulties they are suffering in pronunciation are the exactly the same as those experienced by any foreign language learners, whose fixed set of L1 phonetic categories make their brain select the previous sounds which, being similar to the FL ones, are not the real discrete phonetic categories of that given language, making it hard sometimes for them to be understood by native speakers of that language. Heather's speech therapy, consisting on explicit listen-and-repeat exercises to create new phonetic categories, will certainly improve her pronunciation, never to reach that of a native speaker, but good enough to be understood by them, the same way as FL learners. Cases such as Heather's, provide Applied Linguistics with evidence for a reduced age of cochlear implantation easing overall language acquisition, especially of the establishment of correct sound phonetic categories.

Children implanted at earlier ages seem to have a better facility for implicit grammar, pronunciation and syntax knowledge, and a way higher facility to categorize language sounds into phonetic categories. This suggests children might indeed have a period of higher auditory plasticity during their 0 to 6 years of age that does not affect syntax, grammar and vocabulary as much as the discrimination of language sounds, although the existence of this Critical Period is still questioned by behaviorists. The deaf patients' muted speech seems to be more attributed to language interference from the previously-established phonetic categories, distorted from the muted input signals received before the implantation took place, and which could have been more fixated by time and practice than the new ones, reason why they are selected during the activation process, causing the learner difficulties in this matter. In any case, Heather shows us how either due to Linguistic Interference or to the Critical Period Hypothesis, sound discrimination and pronunciation is one of the biggest difficulties that both FL learners and speakers learning through cochlear implants must face, followed by a need for declarative rules to understand the morphology, syntax, or grammar of a given language.

From Heather we learn the importance of cochlear implantation taking place at an early age for sound production, and language acquisition, but also that children such as Heather, implanted at 9 years old, can still become quite proficient in the learning of oral English language as a FL, especially in the areas of morphology, syntax and grammar. We see how, 9-year-old children who have already developed linguistic cognitive skills by having been exposed to a natural language –The American sign language- can still highly benefit from cochlear implants at the age of 9. Finally, we can observe that, in spite of the disadvantages that cochlear implant surgery has –it being an invasive process, with a 99% success rate, which will limit the children's contact sports they will be able to perform and the aquatic activities too, that the particularity of their accent will be initially misunderstood by speakers of a native language, that sound interferences will still take place up to an extend with the cochlear implants, and the high operation cost, or the deaf pride of their parents, children such as Heather can actually benefit from cochlear implants to “bridge the world within their lives” (Heather in Ted,

Heather's World, 2013), being able to remain taking part in the deaf community while also integrating themselves also into the speaking community.

6. COMMUNICATIVE TEACHING AND CHILDRENS' L2 ACQUISITION

Aside from the cochlear implants, an access to any natural language at an early age in order to develop cognitive language processing skills, as proven by Victor's case, and the age of cochlear implantation, as Heather's example demonstrates, deaf patients will have another variable that will determine whether the patients will become fluent oral language speakers. Other determining factors will condition cochlear implanted patients' success in making the most of their training of their, generatively-speaking, Universal Grammar capacities to master the oral English language: the quantity and quality of the oral input received at the age given, especially if the patients are still young when implanted, as both the Critical Period (Lenneberg, 1967) and the Language Interference Hypotheses (Colomé et al., 2001) defend.

This is why it is so important for early implanted children to receive native L1 input of the oral language and to be instructed according to the Communicative English Teaching approach, and use real-life language in real communicative situations. We will see the cases of 2 children, both implanted at the age of 1. Whereas Nancy, daughter of Sign monolingual parents, taught oral language from an explicit Traditional Transformational Grammar methodology with no real language input but an artificial explicit grammatical one will learn; Shelby, daughter of a speaking L1 mother and set in a communicative school environment with speaking peers will acquire the language. Acquisition looks unconscious and automatized, whereas learning seems to be explicit, slower and not so effective.

6.1. The Input factor. Acquisition vs. learning of an L2: Shelby vs. Nancy's case from Aronson's (2000) *Sound and Fury*, both implanted at year 1

The comparison between the performance of Shelby -daughter of a signing father and a speaking mother- and Nancy's -daughter of signing monolingual parents- illustrates the relevance the kind of language input received has when it comes to SLA. Despite the analysis being only a 1-to-1 comparison, statistics from many studies have supported this advice, now generally accepted: that most foreign language teachers try to focus on the Communicative Language Teaching approach when it comes to teaching young learners, at an age in which acquisition is easier and explicit grammatical learning not so necessary. The single results of the comparison are still significant because although the differences in language processing and especially in language production are so prominent, individual differences are not so decisive in this case. The comparison is useful since both children have been implanted at exactly the same age, places our focus in the environmental differences of the quantity and quality of the oral language input received, in these cases.

Born to monolingual deaf parents, Nancy was implanted at the age of 1. She understands most of what she is told due to her deaf-children school traditional grammar and non-communicative language training, where most contents but some sentences are taught in sign language, but she produces partially understandable speech due to the quantity and quality of the input received. That teaching at school was mostly based on Chomsky's Generative Transformational Grammar, or sentences related to illustrate grammar rules, rather than real everyday language input. Her opportunities to speak were also smaller, because her parents could not provide her with native input in real-life communicative situations; she only had the input of occasional talks with her friends, since the school did not follow the communicative language approach so that she could not receive real-life fluent native input, or practice her skills in order to automatize knowledge. What she achieves with this non-communicative teaching approach plus her friends' occasional input is an understanding of most of what she is being told but manages to produce partially understandable speech, as her following production illustrates:

“My name is Nancy. My brother's name is Marvin. My mum's name is Taryn. My daddy's name is Stan. I live in a town; in New Jersey- I have two my pets and a dog”

ORAL ENGLISH: /maɪ 'neɪmɪz 'nænsɪ/ /maɪ 'brʌðəz 'neɪmb ɪz 'mɑːvɪn/ /maɪ 'mʌmz 'neɪm ɪz 'tɑːrɪn/ /maɪ 'dæd ɪz 'neɪm ɪz 'stæn/ /aɪ 'lɪv ɪn eɪ'taʊn njuː 'dʒeːrsɪ/ /aɪ hæv tuː maɪ 'petz/ /'ænd maɪ dɒg/

NANCY'S PRODUCTION: /baɪ' neɪmb ɪf' neɪfɪ/ /ba' brʌðə' neɪmb ɪf 'mɑːvɪn/ /maɪ 'bʌmz 'neɪm 'stɪstɑːɪm/ /maɪ daɪ'neɪmb ɪf 'dʒeːmb/ /aɪ' lɪf ɪŋ aː eɪ 'taʊn ɪnɪjuː'feːrseɪ/ /aɪ hæv tuː ba pɪ; maː peɪ... ma... 'baː pet/ /heɪ bəː dɔː/

“Well, at school no-one really no-one just speaks, all the kids in my class are deaf, so they signed too, and sometimes they don't speak at all. But when I play with my hearing friends and use my cochlear implant, sometimes I understand them and sometimes I don't”

Nancy in Weisberg & Aronson, *Sound and Fury*, (2000) Retrieved from:

<https://youtu.be/nuhUOCewyKA?t=1166>

Despite having been implanted at the same age as Nancy –at year 1-, Shelby is the daughter of hearing parents who can provide her with fluent, real-life oral English input, and opportunities for practicing her speaking abilities in real-life communicative situations. As a result, she will understand almost everything and produce oral native English understandable speech. Because comprehension comes before production, Shelby's example illustrates the importance for children at early ages, -due either within the 1 to 6 years old Critical Period of language acquisition or to the earlier years in which Language Interference does not take place as much due to a lower fixation of the pre-implanted initial sounds that eases SLA- to receive native speaker fluent input in the language they are going to

acquire. Shelby's comprehension is full and her production is almost native-like proficient, as illustrated below:

“The wheels on the bus go around and round; round and round; round and round. The wheels on the bus go around and round, all through the town”

ORAL ENGLISH: /ðə 'wi:lz ɒn ðə 'bʌs' gəʊ 'raʊnd ɒn raʊnd, raʊnd ɒn raʊnd, raʊnd ɒn raʊnd, ðə 'wi:lz ɒn ðə 'bʌs' gəʊ 'raʊnd ɒn raʊnd, 'ɔ:l 'θru ðə 'taʊn/

SHELBY'S PRODUCTION: /ðə 'wi:lz ɒn ðə 'bʌs' gəʊ 'raʊnd ɒn raʊnd, raʊnd ɒn raʊnd, raʊnd ɒn raʊnd, ðə 'wi:lz ɒn ðə 'bʌs' gəʊ 'raʊnd ɒn raʊnd, 'ɔ:l 'θru ðə 'fə:n/

Shelby in Weisberg & Aronson, *Sound and Fury*, (2000). Retrieved from:

<https://youtu.be/nuhUOCewyKA?t=1572>

Unlike Nancy, Shelby has had access to the communicative real-life situation in which she could practice her comprehension and production of oral English language. Her oral native English-speaking parents and integration into a speaking school provided her with the necessary input of oral English language. Therefore, she could not understand or speak sign language. Knowing that the signal retrieved from cochlear implants is not 100 % accurate; experts such as Napoli (2015) recommend teaching deaf children both sign and oral language once they receive the cochlear implant, so as to make sure that they have access to a L1 in the Critical Period for language acquisition –or during the early years of less previously-established phonetic categories and therefore lower phonetic interference from the L1 pre-implant sounds-. He argues: “All deaf children should be taught a sign language as soon as their hearing status is determined in conjunction with training in spoken language, for their chances of developing a firm linguistic foundation are thus maximized” (p.173).

Finally, Shelby's case shows us how deaf children exposed to a natural language at an early age, or who have been implanted at an early age, can acquire oral English language, -before the critical period of language acquisition for some, and at a time in which earlier L1 rules have not become a fixed acquired skill yet for others-. The requirement being that the input received is enough and that it is a native one, exposed in constant real-life communicative situations provided by interaction with native oral speaking parents or family members. The quality and quantity of the language input received during the first years of life –Critical Period for language acquisition to biological determinists; age of lower language interference to behaviorists-, will be paramount for the comprehension and production of a language, especially its pronunciation. The natural creation of accurate “phonetic categories” (Schovel, 1998, p.51-55) prevents lexical “selection errors” (Kormos,

2006, p.30-31) –also applicable to sounds-, avoiding the erroneous use of previously-acquired language sound patterns in a new language.

7. EXPLICIT TEACHING AND ADULTS' FOREIGN LANGUAGE LEARNING

It has been argued by linguists that late implanted patients will experience comprehension problems with the foreign language to be learnt, that having been past the Critical Period for second language acquisition or after years of lower Language Interference caused by the L2 fossilization of L1 phonetic categories or the affectation of L2 sounds by the fixed distorted pre-implant ones, explicit declarative rules must be taught for patients to understand what is being heard, and that their production will be utterly conditioned by the muted phonetic categories created and fixed in their brains. This will make the cochlear implantation applicable to oral language communication only in those cases who had had already access to a sign language L1 at an early age, and that are willing to undergo extended sessions of explicit instructions of vocabulary, morphology, grammar and especially of sound phonetics or pronunciation.

7.1. Declarative rules and Foreign Speech. Late FL learning: Nita's case from Aronson's (2000) Sound and Fury, implanted at 50

Nita is Heather's mother who, charmed by her daughter's progress in oral English learning as second language, decided to undergo cochlear implant surgery herself at the age of 50. Her case is representative of those who cannot benefit much from cochlear implantation, disclosing age of implantation as the last requirement for deaf people to speak. So far, we have talked of the need to receive oral language input soon through the linguistic relativist Sapir-Whorf (1940) hypothesis, of Victor's case proving how all children should be taught an L1 at an early age, -before year 7 to Critical Period Hypothesis supporters, such as (Lenneberg, 1967) and at an early age to those supporting the Linguistic Interference one, like (Colomé, 2001) - in order to develop the necessary cognitive skills for language processing and subsequent production. It has been noted how important those years are for the creation of phonetic language categories that makes correct pronunciation possible, and two factors have been mentioned which determine performance: The level of exposure to the input of the oral English language and its quality: -whether it comes from a native speaker and it can be practiced in real-life communicative situations, following the communicative language teaching approach-. So now, some last factors must be considered: the age of implantation and the type of formal instruction.

Going back to Shovel's (1998) well-accepted psycholinguistic explanations on language comprehension (p.50-69) and to Kormos' L2 (2006) contributions to Levelt's (1995) L1 speech production module system (p.27-45), one can see that Levelt hypothesized that the production system was divided into modules: a conceptualizer able to choose L1 and L2 concepts were monitor and order them according to the conventions of the language's episodic memory, what is known as the

pre-verbal plan. Next module, a formulator, which receives each concept from the formulator –one at a time- to make the lexico-grammatical encoding of the L1 and L2 lemmas, the morpho-phonological encoding of L1 and L2 lexemes and the application of the explicit declarative rules in the case of an L2. These declarative rules are necessary for the understanding of a foreign language which was not acquired at an early age -during the Critical Period of language acquisition for some, and soon before Language Interference could affect acquisition to others-. Then, and in a parallel way, the phonetic L1 and L2 encoding takes place simultaneously in the formulator, so that the first bit of the message can be sent to the articulator, once the phonetics, grammar, and lexical words have been chosen, as well as their order. The articulator will send the message to the audition module for monitoring and then to the Speech Comprehension System, which will use the conceptualizer and formulator's information to decode the message heard (See Fig.1).

Although Nita has no cognitive language delay because she was taught the American sign language, a natural language, at an early age, -during what biological determinists call her Critical Period of language acquisition and brain plasticity, 0 to years old; or what behaviorists understand as the earlier years in which L1 rules have not yet been previously fixated, interfering with SLA-, by undergoing cochlear implantation surgery at the age of 50 she will be an adult in need of formal instruction in order to understand the foreign language she will hear for the first time: the oral English language. Without the L2 Declarative rules, her formulator module will not have the necessary information for her to formulate messages, sending confused signals to her articulator. Her speech will be therefore reduced to incomprehensible monosyllabic sounds, making cochlear implants fairly useless in her case, unless she underwent sound therapy and many years of explicit formal instruction that taught her the necessary declarative rules to comprehend oral English language speech. As some scholars argue, the elder a person is, the more need of L2 Declarative language rules she seems to require in order to understand the new language. Nita's example provides evidence to the statement that adults have less brain plasticity than children, especially in sound acquisition. Adult foreign language learners will need L2 declarative rules, in order to be able to understand what they hear.

Another issue for people implanted at a late age like Nita is that, because of a late phonological input exposure to oral language, deaf adults receiving cochlear implants at advanced ages for the first time will be able to comprehend if formally instructed, but will have it more difficult to pronounce the oral language and produce clear speech. Even having the necessary declarative rules, adults in Nita's situation will have acquired, learnt and fixated the phonetic categories established naturally in her brain during the Critical Period for SLA, or during the earlier years of life in which Phonetic Interference from the pre-implantation distorted and muted L1 phonetic categories has not been as present yet, affecting SLA in the creation and selection of the new phonetic categories. No matter what sounds she utters, Nita's brain and articulatory muscle memory will have fixated some pre-implant categories for vowels –the most audible sounds-, and some general ones for consonants. As these were formed out of the distorted and muted pre-implant input received, these categories will be

inaccurate and scarcer than those present in the oral English language, especially when it comes to certain consonants. Nita's brain will select sound /b/ when hearing a word beginning with either /m/ or /b/, similar sounds sharing their place of articulation, but not the same manner, for instance. These are difficult for a deaf person to recognize, because of the "mute" quality of the sounds heard up until patients receive the cochlear implant, which make many nasals sound like plosives.

Being long past the critical period for some or the earlier years of lower language interference to others for the nurturing of Schovel's (1995) "Categorical Perception" (p. 54), deaf adults implanted at later ages will have more difficulties in language learning. Adult beginners will benefit from substantial doses of formal explicit foreign language instruction, in order to comprehend and produce the new language before getting into a communicative language teaching class. Speech therapy and constant repetition and explicit knowledge of phonetics and declarative grammar rules is a must for them, whose bigger difficulty will lie in creating and automatizing the new phonetic categories of the foreign language they will be trying to learn, so that later, with great difficulties, and with a variable degree of success depending on the qualities of each individual, they can produce understandable speech.

8. ACQUISITION VS. LEARNING: THE CRITICAL PERIOD HYPOTHESIS

The cases described show differences in the cochlear implanted patients' speech production and comprehension of oral English language after receiving the cochlear implants at different ages. They also show a cognitive delay experienced by children who never have had access to a natural language. Children like Shelby can acquire oral language when exposed to communicative environments at the age of 1. And that adults like Nita, implanted at 50, are at least initially unable to acquire the oral English language as easily as children do, reason why adults are apparently more prompt to learn than to acquire a language, learning oral English as a foreign language. Besides the need for scientific statistical data supporting the already mentioned idea, a question arises about the real cause behind this difference between children-acquisition and adult-learning and about adults' chances to acquire a second language too, in the way children do.

Neurologists as Manrique (1999) share the biologically-deterministic view that there is a Critical Period for language acquisition comprised between the ages of 0 to 6 years old. He talks about "a period of high neural auditory plasticity within the first 6 years of life" (p.193), after which language can no longer be acquired but must be artificially and explicitly learnt, little by little.

According to these theorists, the cognitive delay of feral children deprived from a natural language like Victor and of the non-implanted deaf children born from speaking parents before cochlear implants were possible is irrecoverable, since it would take place outside the margins of the "Critical Period for Brain Auditory Plasticity" (Manrique et al., 1999, p.193). Shelby would have achieved native oral language proficiency because of the nurturing of her Universal Grammar

capacity to categorize sounds into the creation of what Schovel calls “Phonetic Categories” (1998, p.54), possible during this Critical Period of higher brain plasticity, when it is still biologically possible to acquire a language just by communicative exposure. Nancy would not have achieved full language mastery due to her explicit instruction and lack of exposure to native input. Nita will never be able to perform an advanced mastery of a foreign language or be understood when talking, because her brain would have no longer the plasticity necessary to create and acquire the new phonetic categories in which to classify sounds of the newly-accessed oral English language. She would need explicit L2 Declarative rules instruction due to her having accessed the language at an age past the Critical Period for language acquisition, being almost impossible for Heather to achieve a proficient level of oral English comprehension and understanding after the late moment of the implant surgery.

Although strongly defended by some scholars, the Critical Period Theory for second language acquisition is not an absolute. Language acquisition is both a combination of nature and nurture. The Critical Period Hypothesis can justify children’s facility to acquire a language with no need for explicit declarative L2 rules for its comprehension up to an extent, adults keeping on grasping to the phonetic categories of sounds created during this Critical Period for Auditory plasticity, always showing a degree of foreign pronunciation despite the explicit and later automatized training. However, in order for any learning or acquisition to take place, active participation in explicit teaching for adults and in engagement in communicative situations in children is still needed to acquire/learn a given language. The Critical Period, if real, allows children the implicit acquisition of grammar, vocabulary and language sound system, leaving adults in need for L2 explicit declarative rules and phonetic training. Nevertheless, all language progress cannot be explained by biological reasons alone: isolated children do not learn nor acquire language, and exposure and constant practice in every language learning/acquisition has a psychological reality.

If having a psychological reality, Lenneberg’s (1967) Critical Period Hypothesis needs to be complemented with Colomé’s findings regarding (2001) Linguistic Interference and DeKeyser’s (2007) theorizing on Practice and Automatization, in order to understand the origin and characteristics of the foreign talk of deaf patients who receive the cochlear implant at later ages. This also serves to explain how, through constant effort, patients like Heather, implanted at the age of 9, past the alleged Critical Period comprised between the 0 and 6 years, have achieved higher mastery of the oral English as a foreign than it was predicted by her biologically-deterministic doctors.

Another problem of the Critical Period Hypothesis is that it has not been fully proved, having its flaws. A number of issues are raised as consequence of all the cases that have been analyzed, regarding the actual cause for the relationship between their age of implantation and their linguistic performance: What if Victor’s lack of recovery from his cognitive delay was due to his teacher instructing him only in explicit transformational grammar? It is likely difficult to explain how did Heather, contrary to many doctors’ expectations become, despite her foreign accent, proficient in the English language, giving speeches at the university, while having been implanted at 9 years old,

despite her still foreign accent. Was there something else behind Nita's difficulty to utter recognizable sounds, other than her receiving the cochlear implants past the critical period for second language acquisition? It is still an issue whether her brain selected the phonetic categories created out of the distorted and muted input sounds before receiving the implant, turned into what DeKeyser calls "an acquired skill" (2007, p.4-323) that was fixed after years of constant practice or whether her fixation of sounds was merely due to language acquisition within the Critical Period. Was Nita's initial need of declarative rules to understand the L2 due to similar interferences with the rules of sign language?

Scholars still wonder if biological determinism is the real cause behind the younger-implanted patients outperforming the elder ones in language acquisition, or whether it is more a matter of higher fixation of elder phonetic categories and language 1 rules. The latter could result in a progressive Language Interference which can be redressed at any age, despite the long-established internalization of the previous rules having taking place along the years previous to receiving the cochlear implant. Is there a decrease of performance after the Critical Period age of 6 as significant when compared to previous ages as to be able to argue about the existence of the so-called Critical Period for language acquisition? Or is this difference due to a phase that takes place right after when the acquisition of the former language rules has ends, resulting in a faster fixation of the previously-established rules? Whether this degradation in language acquisition after a given age is truly biological, and related to the brain process of lateralization from 0 to 6, or just a mere coincidence has not been fully proven. Neither has why the Critical Period Hypothesis seem to apply more to sound acquisition than to the explicit learning of grammar rules been fully explained.

On the other hand, linguists such as Vanhove (2013, p.4-15), share an empirically supported theoretical position that apparently denies the existence of a Critical Period for language acquisition. Neither does he believe that the period of higher brain plasticity comprised between the ages of 0 to 6 years old for sounds and between 0 to 12 for grammar has real repercussions in language acquisition and learning. Empiricists stake DeKeyser's claim that all knowledge works this way through practice: "declarative knowledge" > "Procedural Knowledge" > "Automatized knowledge" > an "Acquired Skill" (2007, p.4-323) to the extreme. According to these theorists, adults have almost the same biological capacity as children to acquire an L2. The only problem being that fossilization is easier in early ages, in which no Linguistic Interference from an L1 has been fixated enough in the brain as to compete with the new information. Children would benefit directly from procedural knowledge created at an age of no linguistic interference from a previous language, becoming easily an acquired skill. This explains how pre-cochlear implanted children would create a reduced and imperfect set of phonetic categories out of the muted input prior to their cochlear implant surgery, resulting in the muscle-memory fixation of these phonetic categories into an "acquired skill" (2007, p.4-323), which competes for selection with the new phonetic categories learnt from declarative knowledge at an older age, less systematized and therefore, rejected by the brain in favor of approximations from the former phonetic categories.

According to the Language Interference Hypothesis, the need for declarative rules at an adult age would be justifiable on grounds of DeKeyser's systematization of previous L1 rules, interfering in the acquisition of the new ones. In the case of Nita, implanted at 50, the grammar of her L1 sign language would interfere with the one of L2 spoken language, forcing the explicit learning of the latter and her need for explicit declarative rules and phonetic training. This could explain why adult cochlear implanted patients have a higher foreign accent the later they receive the cochlear implant, as well as their need to be in constant practice to turn the newly-learnt "Declarative knowledge" > into "Procedural Knowledge" > "Automatized Knowledge" > "An Acquired Skill" (2007, p.4-323), resulting in the elders learning rather than acquiring the oral English language. Having fixated and turned into a skill the phonetic categories created while mishearing sounds in a muted, distorted and weak way before receiving the cochlear implants, elder patients will have to insist more on making a skill of the new phonetic categories created, be they learning in an implicit or explicit way, -preferable implicit and then explicit to speed the process-.

Their difficulty in acquiring a new language would be due to the systematization of previous language rules turned into skills, which grew with every year of practice, interfering with new still not automatized knowledge. According to this empiricist view, any declarative knowledge can acquire a level of automatization enough to be selected when entering in simultaneous activation with previous knowledge, regardless of when the Critical Period of language acquisition had been. Of course, adult learners will probably need many explicit traditional language teaching before being immersed into the communicative approach, and children implanted at earlier ages will still turn the new knowledge into an "acquired skill" faster, whereas adults would have to go all-the-way-through Declarative, Procedural, and automatized knowledge before turning it into an acquired skill.

For sure, every year's exposure, practice, and subsequent fixation of previous knowledge will negatively interfere or compete with the new one, making it easier for children to acquire foreign languages. But when negating the existence of a Critical Period for SLA comprised between the 0 and 3 years old, this theory argues that regardless of the age, it is possible to master a language proficiently, only the amount of effort and time needed to counter previous fixated pre-implant skills will vary. Sounds would be more problematic simply due to a higher fossilization of muscle memory, rather than because they had been learnt past the Critical Period of brain lateralization. According to this empiricist view, children have it easier to pronounce and understand language sounds and to receive implicit instructions than adults, not because of the latter having been exposed to language past the Critical Period of SLA, but because children are a blank board, and no previous language interfered with or prevented the acquisition of new knowledge. The problem of this view when taken to the extreme is that it does not fully account for the huge amount of vocabulary acquisition children have over adults, or as to why feral children never recover their cognitive skills. It doesn't explain why foreign language learners keep on having a foreign accent despite formal explicit training and subsequent extensive communicative intervention either.

Differences between the Critical Period Hypothesis and the Language Interference Hypothesis only negate each other when taken to the extremes. It seems language acquisition and learning are both a matter of both nature and nurture. Despite the different argumentations to explain the cause behind language acquisition and learning, both approaches coincide in that access to a natural language and to cochlear implantation at an early age helps deaf cochlear-implanted patients acquire and master oral English proficiency, especially when it comes to oral language pronunciation and implicit grammar rules. Real life cases seem to prove a standpoint between the two, reason why both are so hard to be proved in isolation: There could be a higher, if not a Critical Period for the implicit acquisition of sounds and implicit grammar rules which decreases with age, due to a combination of the loss of access to language during the lateralization of the brain and to a higher language interference from the automatization of L1 Grammar rules and Phonetic Categories, which compete for selection with the L2 language-to-be-learnt after cochlear implantation takes place.

When taken to the extreme, both theories have flaws in their totalizing views: the former for having empirical evidence against its argument that outside the Critical Period of brain plasticity comprised from ages 0 to 6, the chances of mastering the phonetic categories of a new language and its grammar rules not being as close to zero after the Critical Period for language acquisition has taken place when everything must be explicitly learnt as Heather's case shows; the latter, in its arguing that any skill can similarly become acquired with practice regardless of the age of study, so long as enough practice is undergone in order to counter the fossilization of previous L1 knowledge: We have empirically seen how foreign accent is quite resilient, through the case of feral children who, like Victor, cannot fully master language, and declarative rules must be learnt by them explicitly overtime. And also through Nita's case, unable to fully master pronunciation and sound comprehension at the age of 50. Acquisition, especially of linguistic sound categories and implicit grammatical rules seems to be the result of both theories: of nature and nurture.

8.1. A Neurolinguistics' study on Sounds, Cerebral Auditory Plasticity and the Critical Period for Language Acquisition.

In his study "Cerebral Auditory Plasticity and Cochlear Implants", Manrique et. al (1999) tries to prove the biologically-deterministic position about the existence of a Critical Period for the language acquisition of sounds, comprised between the ages of 0 to 6 years of age. He claims younger speakers have a higher capacity to acquire language naturally than adults, who often need to learn things explicitly, due to biological causes; more specifically, to the existence of "a period of high neural auditory plasticity within the first 6 years of life" (Lantos in Manrique et. al, 1999, p.193) while the lateralization of the brain lasts, after which language can be no longer acquired but must be artificially and explicitly learnt, little by little.

The authors of the study try to prove the existence of the auditory critical period in language acquisition by analyzing the results of 98 pre-lingual deaf children and teenagers who underwent a cochlear implant at the University of Navarra, in contrast to those of 58 post lingual patients. Manrique et. al argue that because “only those children who were early implanted before the age of 6, achieved a complete open-set speech recognition”, this necessarily proves how “the introduction of auditory stimulation with a cochlear implant cannot restore the loss of neural plasticity out of this critical period” (1999, p.193). Results below show how students implanted before the 6 years old perform better than the ones implanted later, both in vowel recognition, daily word recognition, bi-syllabic word recognition, CID sentence test, and an E.S.P. test (See Fig. 3), all of which test the recognition of sounds.

Although Lantos in Manrique et. al. (1999) argues that these results seem to prove how “the period of neural auditory plasticity” exists; that it “comprises the first 6 years of life” and that “the introduction of auditory stimulation with a cochlear implant cannot restore the loss of neural plasticity out of this critical period” (1999, p. 196), his claims are not without flaws. It is true that his data compares children implanted at the ages (from 0 to 6) with those implanted after this hypothetical “Critical Period of Brain Plasticity for Sound Differentiation” (p.193), showing how the former perform better in sound discrimination tasks than the latter. The age of higher brain lateralization process parallels that of sound acquisition and categorization in his study too. However, Manrique does not provide a plausible scientific explanation for the relation between the auditory cortex expansion and language acquisition other than time coincidence. Nor has he the means to erase other possible variables affecting the higher performance of the cochlear-implanted patients studied; age difficulties can be also due to a higher phonetic interference from systematized pre-implant phonetic categories with the new ones not yet systematized instead, which compete for selection once activated in the speaker’s brain, as the foreign pre-implant muted speech of post-implanted deaf patients suggests, rather than to the language having been acquired during the Critical Period.

Another limitation of his study is the scope of language to which this Critical Period Hypothesis applies. Even if we argue this foreign pronunciation persists in adult foreign language learners despite all efforts at systematization of the new phonetic categories, and admit this to be due to a lack of acquisition of the given latter categories during the Critical Period for auditory plasticity, the data provided only focuses on sounds, not providing enough information for the acquisition of implicit grammar –although the CPH argues so too-, and does not account for the post-CP implanted Heather advanced mastery of other linguistic areas such as Syntax, Grammar, Semantics and Pragmatics.

Although this seems to be valid scientific evidence about “progressive changes taking place in the auditory pathways and centers during the first 10 years of life, being especially dynamic in the first 5 years, when the human being has the most neural plasticity (Lantos in Manrique et al., 1999, p.194), Manrique’s claim that the higher linguistic capacity of children implanted before years of age is necessarily connected to this critical period of language acquisition remains unable to be fully proven

by the results, since his conclusions are based on a coincidence between the better results of pre-6-years-old implanted patients and the presence of this neural plasticity alone, and it certainly proves there is an outperformance of elder implanted by the younger ones, but this does not fully explain the connection between the critical period and this difference in the level of performance, which can be affected by other variables, such as linguistic interference.

8.2. A Cognitive Linguistics' Study on Syntax and The Critical Period for Language Acquisition.

A recent study conducted by Hartshorne et al. (2018), named “A critical period for second language acquisition: Evidence from 2/3 million English speakers”, argues in favor of the existence of a Critical Period for grammar acquisition comprised between the 9 and 12 years. In it, 680,333 immigrants from more than 15 different countries and different ages were asked to answer syntactic tests during their stay in England, showing their progression along the years of practice (See Fig. 5). As Hartshorne (2018) argues, “immersion learners showed only a minimal decline in ultimate attainment until an age of first exposure of 12 years, after which the decline was significantly steeper; non-immersion learners showed no decline until an age of first exposure of 9 years” (p.270). The data is extensive enough to prove how learners between 0 and 12 years old will be able to acquire grammar in an implicit way, whereas those late learners over 12 years old will need of explicit declarative rules to learn and understand oral English as a foreign language, due to their higher difficulty and lower performance.

Despite Hartshorne et al.'s extensive empirical data explains the quantitative difference of grammar language mastery experienced by oral English acquirers and learners, helping us to understand why Nita has bigger problems to understand oral English language and grammar than her younger cochlear implanted counterparts, and will need explicit instruction of declarative rules in order to learn English as a foreign language, the study cannot discard the possibility that differences can be attributed to the fossilization of the L1 grammar rules resulting in a higher grammar interference at elder ages, rather than to the existence of a biological critical period for SLA. However, the fact that the peak of grammatical performance falls dramatically with participants right over 12 years old, suggests that a Critical Period for the acquisition of grammar might have a psychological reality, and that differences in performance can be justified by a combination of the CPH and the Linguistic Interference Hypothesis, explaining how the 50-year-old cochlear implanted Nita, not only will need of declarative rules in order to learn oral English as a foreign language, but practice will be needed to overcome the linguistic interference experienced from the Acquired L1 Sign Language grammar, in relation to her new oral English learning. Again, we would be talking of acquisition and learning as a combination of nature and nurturing.

8.3. A linguistics' revision of the Critical Period Hypothesis

In his paper: "A linguistics' revision of the Critical Period Hypothesis", the behaviorist Vanhove (2013, p.4-15) questions the arguments previous studies use in order to justify the Critical Period Hypothesis. To him, the outperformance of young second language acquirers over later cochlear-implanted learners does not justify the existence of a Critical Period for language acquisition, since the differences shown in the studies can be always conditioned by other variables than exposure to language within a Critical Period in prior years. According to Vanhove's re-analysis of a previous study, "age patterns in second language acquisition are not governed by a critical period" (2013, p.1-15), but by other variables other than the existence of a biologically-determining time for language acquisition. Like many other empirics, he mistrusts the existence of a Critical Period for grammar and for sound acquisition.

Vanhove supports DeKeyser's claim that all knowledge works this way through practice: "declarative knowledge" > "Procedural Knowledge" > "Automatized knowledge" > an "Acquired Skill" (2007, p.4-323), and that adults have nearly the same biological potential as children to acquire an L2; the only problem being Language Interference; that out of constant practice, adult implanted patients have fixated the phonetic categories and grammar rules created during the years they heard muted, distorted input sounds and made automatic grammatical deductions: sets of phonetic categories and grammatical data which compete for selection with the new ones, still "declarative knowledge" (DeKeyser, 2007, p.4-223) and therefore not so automatized. The more the years practicing the old skills, the more difficult it will be for cochlear-implanted patients not to have to resort to declarative explicit learning of grammatical rules and sounds in order to compensate for that.

In order to support his claim, Vanhove (2013, p.4-15) re-interprets the data collected from two previous studies conducted in North America and Israel, with targets showing simple linear regression models between performance in grammatically-judgment tasks (See Fig. 2) and age of onset of acquisition of the different cases analyzed, where more than 50 individuals are considered in the statistics (See Fig. 4). He argues how, according to De Keyser et. al (2010) "a non-linearity in the age of onset of acquisition" constitutes "a necessary condition for accepting the Critical Period Hypothesis of language acquisition" (p.413-438). Vanhove (2013) claims that, were there a critical period for language acquisition, there should be a huge difference between the correlations of grammatically-judgment tasks-score and age of onset of acquisition between the supposed critical period (from 0 to 6 years old) and the rest (from year 7 onwards), following the graphic a "—" shape rather than a "\ " one.

Vanhove's results show performance of grammatically-related tasks becoming uniformly regressive with age (See fig. 4), playing against the existence of any Critical Period for the acquisition of grammar. However, his data analyses cases of learners starting over 12 years old, past the Critical Period age, meaning that what he really proves is the inexistence of a Critical Period past that age

range. There is, however, an “–” shaped graphic in Hartshorne’s (2018) study, with its peak at 12 years of age, showing evidence for acquisition of grammar being easier during that age range than afterwards. What Hartshorne cannot fully demonstrate is that this easier period for grammar acquisition is necessarily due to biological reasons. It might be due to language interference determining factors too, such as in what time an L1 or a pre-implanted language input becomes more fixated once as learners stop learning new sounds or words and begin to erroneously repeat them in the new language.

Because although Vanhove’s (2013) data does not show a natural progressive linear degradation of the innate capacity for grammar acquisition that could suggest that a proportional variable such as interference with previously-established grammar rules could be the only cause behind this difference in performance between more than 10 year old learners and the younger ones, his Critical Period Hypothesis seems plausible, in combination with the Linguistic Interference one, in order to explain these differences and change in variables of performance (See Fig. 6). However, this cannot be fully stated, since further research must be made regarding whether L1 interference can stop being correlative and experience a peak change when the acquirer stops learning new rules and words and starts repeating the former ones, making fixation of L1 grammatical rules more prominent from 10 years old onwards, for instance. Findings seem to indicate the existence of a Critical Period for the acquisition of sounds (from 0 to 6 years) and grammar (from 0 to 12). However, everything explainable from a Critical Period Hypothesis can be argued from a Language Interference one too, opening the doors to either of them being valid, or a combination of both. All the cases portrayed in this work point towards a combination of both factors, however, more studies must be conducted in order to find the real cause behind this age-difference present in acquisition vs. learning, in order to close once and for all, this ongoing linguistic debate.

9. CONCLUSIONS

Deafness is not a cognitive delay but a sensorial deficit that had been marginalizing deaf people from speaking communities for many years. The invention of cochlear implants in 1970 provided deaf children with a replacement for the damaged natural cochlea, allowing patients to hear properly for the first time in their lives. However, in order for cochlear implanted patients to make the most of their prosthesis and be able to understand and speak oral English language, a series of determining factors must be considered, and different teaching methodologies need to be advised for each particular case. Before undergoing the invasive and expensive cochlear implant surgery and giving up one’s capacity to take part in contact sports or water-based activities, one will need to know when it is useful to receive a cochlear implant, and when not, and how can they make the most of the device. The success or failure in oral language proficiency experienced by the different cochlear implanted

patients will vary depending on the age of implantation, type of input received and kind of teaching methodology applied.

The Applied Linguistics' analysis of the different real cases of cochlear-implanted patients and the analysis of their differences in comprehension and production of oral English language answers most of these questions in relation to cochlear implants, foreign language learning and second language acquisition. Victor from Truffaut's documentary *The Wild Child (1970)* shows the importance for deaf children to be diagnosed and implanted early and be taught sign language at an early age, to prevent their lack of access to a natural language resulting in a cognitive delay. Studies such as Manrique's (1999) for the Critical Period of Auditory Plasticity, Hartshorne's (2018) for the Critical period of Grammar acquisition and those in favor of the Language Interference Hypothesis (Colomé, 2001) explain the capacity of children to fully acquire the sounds and rules of a language in real-life communicative native environments, reduced into a capacity for learning a new language through explicit teaching of phonetics and grammar declarative rules once they reach adulthood, each theory in its own way.

Heather from Aronson's documentary *Sound and Fury (2006)*, a daughter of signing monolingual parents who receives the cochlear implant at the age of 9, teaches us about the psychological reality of Schovel's (1998) categorical perception, and specifically informs us on how deaf children acquired muted distorted sounds from their pre-implant oral English input, which compete for selection with the new phonetic categories of the post-implant oral English sounds, as argued in Kormos's (2006) modification of Levelt's (1995) module language production system. Explained by DeKeyser's concept of practice as means to turn declarative knowledge into an acquired skill, Heather undergoes explicit phonetic training, so that the new phonetic categories can be selected over the former ones. Her impossibility to get rid of her foreign speech when talking oral English can be taken as an argument to support both the Critical Period Hypothesis and the Language Interference one, although this is difficult to prove, given the many variables conditioning children's acquisition and learning. Because Heather is still 9 years old and arguments suggest the Critical Period for grammar acquisition lasts until the age of 12, in her case the best training for her is to be integrated in speaking schools at the same time she is explicitly taught speech therapy, needed when the critical period of 6 years old is over. Even if the Critical Period does not exist in biological terms, and it is just the period of time in which Linguistic Interference is lower due to issues of L1 practice and interference, acquisition of grammar is still higher in children than in adults, whose fixation of previous grammar rules and phonetic categories can make the explicit learning of Grammar and Phonetics necessary.

Shelby and Nancy from Aronson's documentary *Sound and Fury (2006)* show us the importance of the quality of the oral language input received by children, in order to become proficient speakers of the oral English language in the future. Young children show a higher capacity to acquire the sounds and grammar of a language, be it due to the existence of a Critical Period of language acquisition, to pre-implant fixation of L1 data and subsequent Linguistic Interference or to the most

plausible answer: due to both. This is why children benefit more from a communicative language teaching method than to a traditional explicit grammatical one, since implicit learning tends to be more effective, especially in the areas of phonology and grammar. Born out of deaf parents and sent to special schools for deaf children, Nancy is exposed to a reduced and traditional grammatical teaching of oral English, allowing her a partial learning of phonetics and grammar, whereas Shelby, also implanted at the age of one but daughter of a native oral English-Speaking mother, acquires a full mastery of pronunciation and grammar: thanks to her exposure to real-life input and communicative situations. It seems that Traditional Grammar can be useful to teach late implanted patients the necessary declarative rules, but for children capable of acquiring the language, having a real-life native input will have a bigger impact in their future pronunciation and mastery of the language, since they can make the most of their Universal Grammar human capacity to acquire a new language.

Nita's case from Aronson's documentary *Sound and Fury* (2006), implanted at the age of 50, highlights the importance of declarative rules and formal traditional instruction in late foreign language learners whose critical periods for the acquisition of sounds and grammar rules are over, or whose fixation of former language rules prevents their acquisition and forces the adult to learn phonetics and grammar through a series of declarative rules and explicit instructions. She serves the purpose of illustrating how later-implanted patients can make little use of cochlear implants unless they want to undergo formal and extensive language instruction. Even so, their level of proficiency will hardly ever be equal that of a native speaker. Nita has fixated pre-implant muted distorted phonetic categories for quite a long time, has built the muscle memory necessary for that, and has the linguistic interference of her sign language grammar rules and is past the critical period for the acquisition of both skills, if the given periods truly exist. In order for Nita to produce understandable speech and recognize the sounds and rules of the oral English, she must become a foreign language learner of that language, receiving explicit formal instruction before. In these cases, traditional and explicit grammar teaching and phonetics is advisable, up to the point of making the speaker familiar with the language long enough to be able to take place in communicative teaching lessons.

Whether a biologically-determined Critical Period for grammar and sound acquisition really exists, or differences in performance triggering language acquisition in children and learning in adults are due to Linguistic Interference from L1 rules and sound categories fixed out of practice is still to be seen. Evidence in this work hints at a Critical Period for Grammar (from 0 to 12 years old) and another for Sound acquisition (from 0 to 6) having a psychological reality, together with Language Interference resulting from a higher automatized pre-implant L1 phonetic categories in a period in which linguistic interference was less affecting SLA. These latter activate together with the post-implanted new phonetic categories and declarative rules for selection, creating problems and forcing adult implanted patients to become foreign language learners. Still, both arguments remain theories, and are still to be scientifically proved. What is known for certain is that children can acquire the sounds and grammar of a language, whereas adults need of explicit training.

The analysis of the data and arguments shown in Lantos et al.'s in Manrique's (1999) "Cerebral Auditory Plasticity and cochlear implants" proved how children implanted before the age of 6 perform better at sound recognition than those implanted afterwards. The same happens with Hartshorne's study on grammar (2018), which shows children from 0 to 12 outperforming later learners at elder ages at grammar tasks, showing that age is key to differ between child learners acquiring a language and having to learnt it explicitly in adulthood. However Lantos et al.'s in Manrique (1999) attribution of these results to the existence of a Critical Period for Sound acquisition is mainly based in a coincidental parallelism between brain lateralization and age of implantation in which progress in sound recognition is higher, further evidence being needed to find out whether the real cause behind the easier acquisition of sounds at earlier ages is due to the biologically-determined cause of a Critical Period Hypothesis for sound acquisition between the ages of 0 and 6, or if the Linguistic Interference resulting from the fixation of previous pre-implant phonetic categories through extensive practice to become an acquired skill is the real factor behind that.

The same happens in the case of Hartshorne's (2018) study on grammar: whether a Critical Period for grammar acquisition takes place between the ages of 0 to 12 or it is conditioned by L1 Interference is still a subject to debate. Vanhove (2013) questions the technical validity of CPH results to prove the existence of a biologically-determined critical period for language acquisition, arguing in favor of favor of Language Interference as responsible for the differences of performance with age. Although Hartshorne's (2018) study shows a discontinuity in the relation between age of language immersion and performance that can is probably attributed to the existence of the given biologically-determining Critical Period, it can also be caused by variables in L1 acquisition – as higher fixation taking place after the learner or acquirer stops receiving new language knowledge and focuses on repetition alone- and their subsequent Interference in the learning of an L2.

The Critical Period Hypothesis and the Language Interference one both agree in that younger implanted patients have more facilities to acquire oral English language than elder adults, who will need explicit training in order to learn the oral English language. Whereas neurologists like Lantos in Manrique (1999) are more skeptical about patients implanted later being able to acquire the oral English language to the same level of proficiency as that of a native speaker, linguists like Vanhove (2013) open the doors to the possibility that later learners might achieve well, if receiving an explicit phonetic and grammatical instruction followed by interactions in communicative situations, so as to make of the new procedural knowledge a skill to compete for selection with the previous fixated distorted oral language input. Language acquisition is both a matter of nature and nurture, not only of the Universal Grammar capacity to categorize sounds into phonetic categories through practice but to acquire the rules of given language, or learn them explicitly, depending on the age of the learner. The type of training will also vary: adults must learn sounds and grammar explicitly, while children can benefit from an implicit acquisition of such knowledge.

Applied linguistics helps us join different disciplines to overcome everyday linguistically-related problems. In this case, the analysis of different individual cases and empirical studies of implanted patients at different ages and in different linguistic environments helps the theorist prove the psychological reality of many linguistic theories, advising on matters such as in which cases is cochlear implantation worth the money and the risk and also on which learning methodologies should each particular patient focus in order to make the most of their restored auditory sensor, so as to make communication with the speaking world possible, encouraging social integration, acceptance and the bridging of the gap between the deaf and the speakers' worlds.

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APPENDIXES

Figure 1

Kormos' (2006, P. 150-162) revision of Levelt's Modular Production Model, showing the differences between L1 and L2 regarding the use of declarative rules.

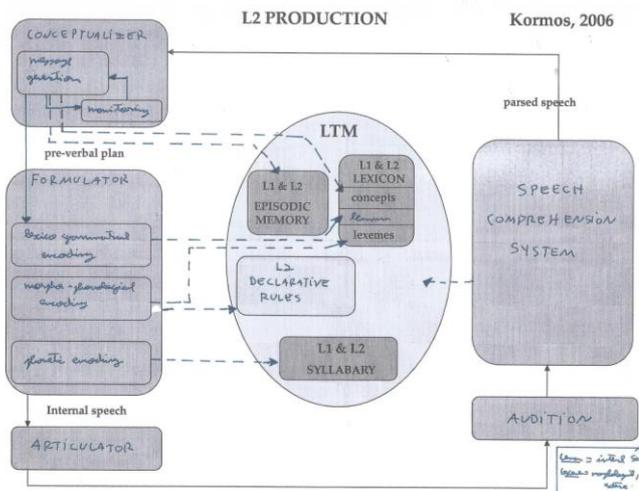


Figure 2

Sample of a grammatically-judgment task.

No.		grammatical	ungrammatical	I'm not sure!
19	I knew it would happen.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
20	He has the worst handwriting I've ever seen!	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
21	This is the girl that I told you about her.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
22	The woman, who later died in hospital, has not yet been named.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>

Figure 3

Results from Manrique et. Al's study (1999, p.193).

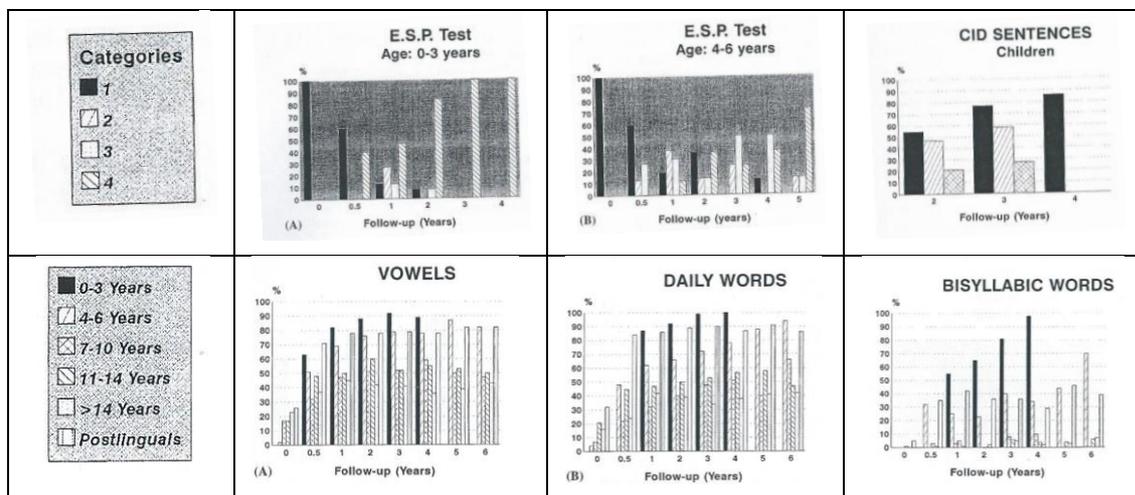


Figure 4

Results from the Israel and American comparative study, in Vanhove (2013, p.5).

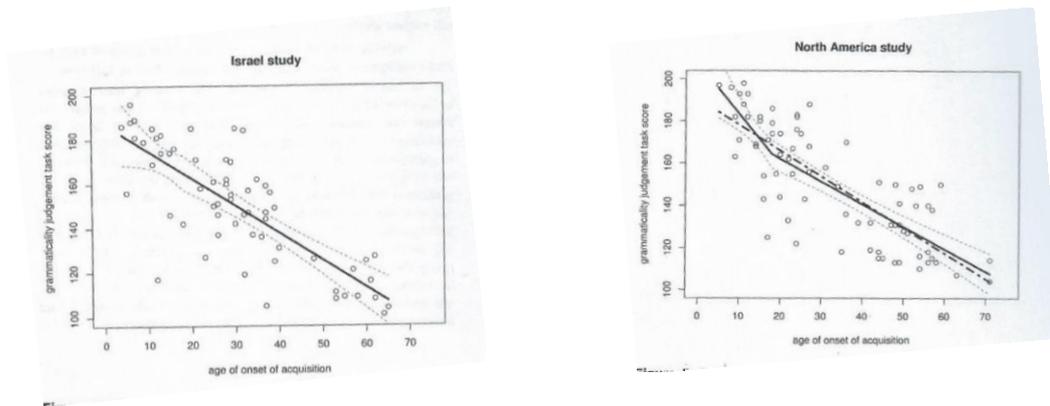


Figure 5

Ultimate attainment for monolinguals, immersion learners and non-immersion learners, after 3 years: It was higher for monolinguals than for bilinguals. In Hartshorne et al. 270 (2018, p.270) .

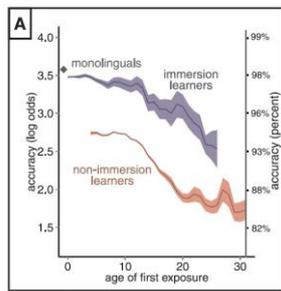


Figure 6

Comparison of Lantos (1999), Hartshorne (2018) and Vanhove (2013)'s results.

