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Age constraints in phonological learning: On the relevance and efficiency of pronunciation training

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ABSTRACT Accent has shown to be one of the most salient features of speech. Listeners are particularly sensitive to *foreign* or L2 accents, which are phonological variations attributable to L1 influence on the L2. At the same time, L2 accents are very hard to overcome. As L2 research has shown, pronunciation is the language skill which is most difficult to master, especially late in life. The need for efficient pronunciation instruction in schools and tertiary institutions is therefore undeniable. The chapter at hand provides a literature review of whether pronunciation instruction can be efficient, given maturational constraints with growing age. It investigates the existence of neural plasticity in adults in terms of phonetic learning as well as phonological attainment in adult L2 learners and will thus show that pronunciation training can be efficiently used in adult language instruction.

KEYWORDS neural plasticity, phonological acquisition, phonological proficiency, pronunciation training, speech perception and production

1 INTRODUCTION

> Simply phonetics. The science of speech. That's my profession; also my hobby. [...] You can spot an Irishman or a Yorkshireman by his brogue. I can place any man within six miles. I can place him within two miles in London. Sometimes within two streets.
> — Shaw, Pygmalion, 1.118

The note taker's comments in the first act of *Pygmalion* very well express how salient of a feature *accent* is. Investigating accents (i.e., manners of pronunciation differing from the standard variety, for instance based on speakers' local, ethnic, or socio-economic background), native as well as non-native, is one of the key aims in the linguistic field of phonetics. Yet this salience of accent is not restricted to professional phoneticians. In fact, listeners seem to be remarkably aware of accents and constantly make judgments about their interlocutors' heritance based on their speech. Listeners prove to be especially sensitive to *foreign* or L2 accents, or in other words, to phonological variations attributable to L1 influence on the L2 (Derwing & Munro, 2009). Studies have shown that listeners can detect L2 accents in only 30 ms of speech, in speech played backwards, and even in languages unknown to the listeners (e.g., Flege, 1984; Major, 2007).

In spite of our apparent awareness of foreign accents in the speech of others, it seems to be a different story when it comes to adapting our own accents to a new target language. L2 pronunciation has indeed been attributed with a special status in L2 learning; there seems to be a certain consensus among linguists that pronunciation is the language skill that is most difficult to acquire with high proficiency, especially later in life, after adolescence (see, e.g., Long, 1990). Interestingly, several studies on learners' conception with regard to accent revealed a high importance attributed to highly proficient pronunciation in the target language. In a study with 400 EFL (English as a foreign language) students, Timmis (2002) found that 67% of the students attested to seeking native-like pronunciation in English (see Werk, 2012, for similar results). Derwing (2003) conducted a study with 100 ESL learners, who were asked whether they would take a magic pill, if one existed, to wake up speaking En-

glish with a local accent; 95% of respondents answered with the affirmative.

Furthermore, the expanding role of English as an international language clearly highlights the importance of successful interactions between speakers from different linguistic backgrounds. The focus of pronunciation instruction and research has, accordingly, shifted from native-like models towards concepts of *comprehensibility*, which means how easy it is for the listener to understand an utterance, and *intelligibility*, which means how much of an utterance the listener actually understands (Derwing & Munro, 2009.) As Busà suggests, "interlanguage communication rests on the concept of mutual intelligibility, and pronunciation is one of the main factors contributing to it" (2008, p. 113f.). Several studies, in fact, found a positive effect of pronunciation training on the intelligibility of L2 learners' speech (see, e.g., Derwing et al., 1997, 1998). It has thus been argued that L2 instruction should focus more strongly on learners' pronunciation proficiency to ensure successful communication in multi-linguistic contexts (see, e.g., Busà, 2008).

Regarding pronunciation as one of several language skills to be acquired for successful communication, the need for sufficient pronunciation training is certainly understood. As Thomson and Derwing (2014, p. 14) note, "pronunciation instruction is no longer a neglected domain of second language teaching and research". The major aim of the current chapter is to investigate whether it is still possible to achieve a high level of pronunciation proficiency in an L2, considering different maturational constraints learners experience with growing age. The first section will focus on studies from L1 acquisition to explain the emergence and background of L2 accents. The next section will examine the aging brain and discuss neural plasticity in terms of phonetic learning, followed by a section on *ultimate attainment* in L2 phonology in adult learners. The final section will draw a conclusion on whether it is still possible for adult L2 learners to overcome pronunciation difficulties based on the reviewed literature.

2 THE CRADLE OF L2 ACCENT

When learning a new language, the majority of learners are faced with the challenge of acquiring a new sound system and *speech melody* (i.e., prosody). This challenge apparently increases with growing age (i.e., after adolescence), leaving adult L2 learners to struggle with negotiating the typical pronunciation pattern of their native language and the new, unfamiliar accent of the target language. The result is often a more or less noticeable foreign accent in the L2. Linguists have been highly interested in this seemingly insurmountable phenomenon of target, or native-like, accents. To fully tackle the question of where L2 accents actually come from and why it is so difficult for older learners to adopt a native-like pronunciation in an L2, we need to shed light on our early childhood years.

Interesting insights into the issue of *foreign accentedness* can be gained through studies of L1 phonological acquisition. Several early behavioral as well as brain-based studies in this field have shown that newborn infants are able to discriminate between speech sounds irrespective of their native language, an ability that is no longer present in adults. Werker and Tees (1984) revealed a top-down process of phonological development of infants by testing the discrimination performance of a Hindi dental-retroflex contrast by Hindi and English-speaking infants throughout their first year of life. They found that the initial ability to detect this contrast drastically altered in the English-speaking infants starting at ten months of age. Cheour et al. (1998) confirmed the existence of a top-down process in the acquisition of phonology through *mismatch negativity* (MMN, Pulvermüller & Shtyrov, 2006) experiments. They tested Finnish and Estonian infants' brain responses when discriminating the Finnish/Estonian phonemes /e/ and /ö/ and the exclusively Estonian phoneme /õ/. The MMN amplitude generally increases with an increasing acoustic difference between standard (i.e., /e/) and deviant stimuli (i.e., /ö/ and /õ/). At six months of age, the Finnish infants had larger MMN responses for /õ/ than /ö/ compared to /e/, which was the acoustically more different stimulus; at one year, however, their MMN amplitude was smaller for Estonian /õ/ than for Finnish/Estonian /ö/. Estonian one-year-olds exhibited a slightly larger MMN amplitude for the acoustically more different /õ/ than for /ö/. Cheour et al. thus tracked

the development of *language-specific memory traces* in the infant's brain between six and twelve months, which apparently enables the growing infant to discriminate between the phonemes of their mother tongue.

More recent studies have confirmed that children apparently move from a language-universal perception of speech at birth to the language-specific speech perception of their native language over the course of their first year (e.g., Bohn, 2000; Kuhl, 2004; Kuhl et al., 2008). This shift in children's speech perception occurs very early in life. Starting in the first few months, children become increasingly focused on the sound system of their ambient language, a process that is necessary to acquire speech. As Bohn (2000) writes,

> [...] the learning task of infants and children is not to become sensitive to more and more differences among sounds, but to selectively enhance or suppress initial sensitivities to yield perceptual patterns that are needed for efficient processing of the L1 (p. 6).

According to Kuhl et al. (1992), who tested the discrimination performance of English and Swedish-speaking infants throughout their first year, this sensitizing process starts to work as early as six months for vowels. Perception of consonants has shown to become affected at approximately ten months of age (Kuhl, 2009).

Although vital for L1 acquisition, this process of *phonetic narrowing* influences children's perception of speech sounds beyond the native sound repertoire. Kuhl (e.g., 2000, 2004, 2009) developed the so-called *native language neural commitment* (NLNC) hypothesis to account for the strong impact of the native language on children's phonetic discrimination. The NLNC hypothesis was supported by behavioral and brain-based tests (Kuhl & Rivera-Gaxiola, 2008) and implies that due to the influence of the ambient language, children's native language abilities increase while their non-native abilities decrease: "By the end of the first year, the infant brain is no longer universally prepared for all languages, but primed to acquire the specific one(s) to which they have been exposed" (Kuhl, 2009, p. 106).

Kuhl's (2009) NLNC hypothesis shares striking similarities with the *Natural Phonology Theory* proposed by Stampe (1969, 1979), in which phonology is based on a set of universal and interacting phonological

processes. In their language acquisition process, infants learn to suppress those phonological processes that do not apply to their native language. Donegan and Stampe (1979) explain how such language-specific repression mechanisms affect, among other processes, L2 pronunciation in adults:

From adolescence, usually, there is little further change, and the residual processes have become the limits of our phonological universe, governing our pronunciation and perception even of foreign, invented, and spoonerized words, imposing a 'substratum' accent on languages we subsequently learn, and labeling us as to national, regional, and social origins (p. 127).

This shift in children's phonological system elaborated by Kuhl (2009) and Donegan and Stampe (1979) thus also explains the difficulty encountered by many adult language learners in properly perceiving and producing the sound pattern of a new language. Children, however, can still reverse this process when exposed to another language. Experiments with American infants of nine months showed that short-time exposure to Mandarin Chinese resulted in phonetic learning in the target language (Kuhl et al., 2003). Adults, by contrast, are less likely to overcome those early-acquired perception constraints.

The early changes in children's speech perception and the resulting difficulties in pronunciation experienced by adult L2 learners raise the question of whether it is still possible to overcome these constraints and acquire proficient pronunciation ability in an L2 later in life. The following sections will focus on neural plasticity as the neurophysiological prerequisite that is necessary for phonetic learning and will then discuss relevant behavioral and neurolinguistic experiments on ultimate attainment of pronunciation in adult L2 learners.

3 NEURAL PLASTICITY IN ADULTHOOD

> [...] the wiser mind mourns less for what age takes away than what it leaves behind.
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> — Wordsworth, *The Fountain*, 34–36

A highly relevant question in adult L2 acquisition is the extent of plasticity in the aging brain. The notion of *neural plasticity*, which can be defined as "the brain's capacity to get organized and to reorganize itself as a reaction to internal or external changes", has eradicated the long held idea of the brain as a physiologically static organ (Peltzer-Karpf, 2003, p. 369). In fact, ongoing research in the field of cognitive neuroscience has provided clear evidence for learning-induced neural plasticity in adults (Brown et al., 1991; Levi-Montalcini, 1998; Pascual-Leone et al., 2005; Rakic, 2002; Zhang & Wang, 2007).

It is well known that neural plasticity does slow down after several growth spurts until early adolescence (Peltzer-Karpf, 2003). However, the brain can compensate for such changes by reorganizing the given repertoire in the form of a "remodeling of connections", which includes dynamic processes such as rewiring the cortex, using alternative circuits, and reorganizing cortical maps (Peltzer-Karpf 2003, p. 377). As Peltzer-Karpf (2003) states,

> [...] though the human brain may have to suffer the loss of certain neurons and to undergo biochemical alterations at an advanced age these changes do not bring about a noticeable loss of cognitive and creative capacities (p. 391).

The existence of neural plasticity throughout adulthood has important implications for the processes involved in L2 acquisition. From the current perspective, it can be argued that "language learning is not an irreversible age-bound event" (Zhang & Wang, 2007, p. 154). It has further been shown that younger and older learners, despite the fact that their neural networks differ, undergo similar paths in the acquisition process and also use comparable mechanisms during the early stages of acquisition.

A more problematic situation within the domain of L2 acquisition is attributed to *phonetic learning* (Peltzer-Karpf, 2003), considering the early transition from a language-general to a language-specific speech perception as discussed above. Zhang and Wang (2007) argue that the perceptual reorganization involved in this transition reflects "a continuous process of neural commitment towards the first language and gradual decrease in neural plasticity to acquire another language" (p. 148).

Behavioral studies have shown that adults are generally less successful in differentiating between non-native speech contrasts than young learners (Strange, 1995). As Flege et al. (1996) have shown, sounds that are acoustically close to L1 phonemes are particularly difficult to acquire for late L2 learners. These findings were supported by neurophysiological studies, which provided evidence of *memory traces* for language-specific phonemes in the adult brain (Cheour et al., 1998; Näätänen et al., 1997; Rivera-Gaxiola et al., 2005). Näätänen et al. (1997) found higher MMN and MMNm activity for native vowel discrimination despite larger acoustic differences in non-native contrasts.

Zhang and Wang (2007) claim that this "loss of perceptual sensitivity for non-native phonemic contrasts" described above is quite difficult to reverse in adulthood since "the brain would have become committed to the analysis of native language structure with reduced neural sensitivity for non-native speech perception" (p. 148). However, the authors strongly highlight the prevalence of linguistic experience over such biological and maturational constraints in the acquisition process, which influences language-related cortical responses (see, e.g., Binder, 1999; Gaillard et al., 2000; Yetkin et al., 1996). Learners' proficiency levels as well as the typological proximity between L1 and L2 are further related to plasticity in the brain (Abutalebi et al., 2001; Mehler & Christophe, 2000).

Despite early neural commitment to the native language, it can thus be argued that linguistic experience can still enhance the perceptual skills of adult L2 learners. As Zhang and Wang (2007, p. 152) conclude, "early language exposure does not produce the complete loss of sensitivity to nonnative distinctions". Accordingly, it is still possible to reverse the NLNC process and to develop sensitivity towards non-native speech contrasts even in adulthood. Enriched linguistic experience in the form of specialized phonetic training has shown to be of particular relevance in achieving this reversal.

A great variety of studies have shown that intensive short-term training methods can improve the perception of non-native speech in adult learners, which can be interpreted as a sign of neural plasticity (Akahane-Yamada et al., 1997; Bradlow et al., 1999; Hazan et al., 2006; Iverson et al., 2005; Jamieson & Morosan, 1986; Logan et al., 1991; McCandliss et al., 2002; Pruitt et al., 2006; Strange & Dittmann, 1984; Tremblay et al., 1997; Wang et al., 2003). For example, Zhang et al. (2000) developed a

training software that is based on the features of child-directed speech such as acoustic exaggeration and visible articulation cues. Testing a group of Japanese adults with little previous English exposure, they found a highly significant improvement in the perception of the /l/ – /r/ contrast, as well as enhanced neural sensitivity and efficiency. The authors conclude that, given such enriched linguistic experience, "there is substantial neural plasticity for the acquisition of new phonetic categories in adulthood" (Zhang & Wang, 2007, p. 152). Moreover, Winkler et al. (1999, p. 638) conducted MMN experiments with Hungarian learners of Finnish on the Finish phonemes /æ/ vs. /e/, revealing a "dynamic nature of cortical memory representations for phonemes in adults". Their study provided evidence that training in an L2 elicits the formation of new phoneme representations in the adult brain, which further indicates the existence of neural plasticity at an advanced age.

Phonetic training can thus lead to clear improvements in speech perception of an L2. Perceptual learning has shown to have an effect on the participants' production skills in the target language as well. Several studies have documented a transfer of improvements in perception to the production domain (e.g., Callan et al., 2003; Zhang et al., 2001). Zhang et al. (2001) thus conclude that neural plasticity can be induced in adult L2 learners through specialized phonetic training (Zhang et al., 2009).

4 L2 PHONOLOGICAL PROFICIENCY IN ADULTS

The fact that children can easily acquire the sound system of a new language implies the existence of a *sensitive period* for language learning (Kuhl, 2010, see also Resnik in this volume). Non-native phonetic contrasts can be easily integrated by children, yet not by adult language learners. Various studies have been conducted on the offset of this ability, although with differing conclusions. So far, no exact age can be consistently determined that could be said to mark the end of a sensitive period for L2 phonology. Instead, the majority of studies reported the absence of a sharp discontinuity in age, which consequently implies a linear, gradual decline in pronunciation ratings (see, e.g., Flege et al., 1995a, 1999).

There is still a certain consensus among empirical studies regarding a negative correlation between the age of language acquisition and the attained proficiency level in pronunciation. Therefore, younger language learners seem to have a clear advantage regarding ultimate phonological proficiency, both in perception and production (see, e.g., Abrahammson & Hyltenstam, 2009; Burda et al., 2003).

However, this does not rule out the possibility of achieving phonological proficiency late in life. The aging brain is still active and can also adapt to environmental experiences such as language input. Evidence of learning-induced plasticity thus shows that the neurophysiological prerequisites for efficient language acquisition, and phonetic learning in particular, are still in place throughout adulthood (see, e.g., Peltzer-Karpf, 2003, 2012; Zhang et al., 2009; Zhang & Wang, 2007).

These findings were supported by a number of behavioral experiments which showed that adults are still able to overcome barriers to pronunciation. Bongaerts et al. (Bongaerts, 1999, 2003; Bongaerts et al., 1995, 1997, 2000) conducted a series of experiments focusing on phonological attainment in exceptional cases of late L2 learners. The participants consisted of carefully selected highly proficient late learners of English or French with a Dutch language background, who studied the target language at university. In each study, several of the learners were rated as native speakers in the target language by native evaluators. These results are in line with other studies on phonological attainment of non-exceptional late L2 learners (see, e.g., Derwing et al., 2014; Flege & Eefting, 1987; Flege et al., 1995b; Moyer, 1999), which proved that adult language learners may still be able to acquire authentic L2 pronunciation under special conditions such as intense pronunciation training.

In light of these results, age cannot be the only determining factor for L2 phonological proficiency. In his studies with highly proficient late L2 learners, Bongaerts (1999, 2003) identified at least four additional factors likely to influence ultimate attainment. First, the motivation and importance attributed by learners to phonological proficiency has shown to play an essential role in their success. Second, a further important role was attributed to continued and substantial authentic input in the target language. Third, intensive training in the perception and production of speech sounds in the L2 was assumed to have contributed to the participants' high phonological proficiency. And finally, an increased awareness

of the phonetic contrasts between the native and the target language was attested to have had positive effects on participants' pronunciation as well.

From the perspective of such phonetically-oriented studies, focusing primarily on external factors such as age of onset, motivation and intensive training and L2 input, it is possible to create ideal conditions for phonological learning and thus foster ultimate phonological achievement in the target language. Still, the question remains of why some individuals integrate the sound system of a language more easily and faster than others. Recent studies in the field of cognitive neuroscience have shifted the focus to physiological factors inherent to the learner, such as special genetic equipment to account for differences in learners' ability and velocity in acquiring L2 phonology, as will be outlined in the following. The underlying assumption is that some language learners are innately more talented than others and that language aptitude is genetically inherent in the learners' brain.

In an early study on the neurological substrates of linguistic talent, Geschwind and Galaburda (1985) found a connection between *pathological language talent* and enhanced growth of particular brain areas. Jilka et al. (2007) investigated neuronal correlates of talent in a large-scale study, in which they conducted fMRI (functional magnetic resonance imaging) scans with subjects classified according to different degrees of talent while performing phonetic perception and production tasks. Their results suggest higher brain activation in untalented speakers, indicating that "high proficiency correlates with reduced effort in speech production, and enhanced cortical efficiency" (Jilka et al., 2007, p. 256). Further, MRI scans investigated with the VBM (voxel-based morphometry) method revealed a connection between individual differences in the perception of foreign speech sounds and the anatomy of the left auditory cortex white matter (Golestani et al., 2002), as well as between the accuracy of foreign speech sound production and white matter anatomy in brain regions involved in articulation and phonological working memory (Golestani et al., 2007). In spite of such compelling evidence, further neurolinguistic studies are necessary to determine neurological substrates of language talent as well as the effect thereof on the adult learners' brain.

Even though the existence of individual *language aptitude* would imply that some aspects of language learning could be immune to the external factors outlined before, Bongaerts' (1999, 2003; Bongaerts et al., 1995, 1997, 2000) findings are still highly relevant in assessing ultimate attainment in late L2 learners. In fact, he focuses on the interaction of several different factors, even including innate talent since his participants are selected cases of highly proficient L2 users. To conclude, the behavioral studies with highly proficient late language learners clearly show that it is still possible to attain native-like proficiency in an L2 in adulthood. In line with those findings, Bohn (2000, p. 11) remarks on the "malleability of language-specific patterns of perception", suggesting that the influence of the selectivity process during early infancy is powerful, but not all-pervasive.

5 CONCLUSION

Can old brains learn new language tricks? Judging from the studies reviewed in the present chapter, the answer to this question seems to be yes. Neurolinguistic evidence suggests that our brain is still malleable. Also, studies on phonological attainment show clear evidence that it is still possible to attain a native-like accent as an adult. It can thus be concluded that phonetic training is still relevant in adulthood and can be efficient even at an older age.

The human brain still exhibits plasticity during adulthood, which is needed for efficient processing of a new language. Numerous brain-based studies have shown that language experience, and specialized phonetic training in particular, can indeed induce neural plasticity. In spite of early neural commitments to the native language system, phonetic learning is therefore still possible in adults. The notion of critical or sensitive periods for language acquisition should consequently be re-evaluated in linguistics. As Zhang and Wang (2007, p. 154) aptly suggest, "language learning is not a strictly timed developmental process with rigid cut-off period" (see also Hakuta et al., 2003; Wang et al., 2003b).

Similar findings were gained by behavioral studies, which have shown that late learners are still able to attain a high or even native-like level of

phonological proficiency in a new language. Ultimate attainment in L2 phonology must therefore be multiply determined, with several further influencing factors in addition to age. Motivation, sufficient language input, phonetic awareness, as well as phonetic training were all identified as key factors for a high proficiency in L2 phonology.

It can thus be concluded that intense pronunciation training can help adult learners overcome age-related disadvantages in achieving authentic L2 pronunciation (see also Lee et al., 2015; Thomson & Derwing, 2015, for a literature review). Pronunciation has recently been granted more focus in the language classroom, yet the crucial question remains of which training method works most efficiently. One major incentive of future research in this area would thus be to investigate different methods and models of pronunciation instruction, as well as to examine the efficiency of specific technologies which could be effectively used to complement regular classroom instruction.

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