Second language phonology: The role of perception

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second-language phonology: the role of perception

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introduction

It is well known that adult learners have great difficulty when attempting to learn the sounds of a second language (L2), as observed in the phenomenon commonly known as "foreign-accented speech." Despite the fact that adults have well-developed cognitive capabilities and have superior abilities for many complex learning and problem solving tasks, if the task is to learn the sound system of a language, adults are generally outperformed by children. How can we explain this paradox? This chapter builds a case to show that the explanation crucially involves perception.

In early phonological theory, the role of perception in explaining the performance of L2 speakers was taken seriously, as shown by the writings of Polivanov and Trubetzkoy in the first half of the twentieth century. Polivanov (1931/1964) claimed that the consonant and vowel phonemes of an L2 are perceived through the first language (L1) sound system, so that difficulties in the production of L2 sounds were viewed as a consequence of the influence of the L1 in perception. Likewise, Trubetzkoy (1939/1969) believed that inadequate production of L2 sounds had a perceptual basis, suggesting that the L1 system acted as a "phonological filter" through which L2 sounds were perceived and classified. Despite these early perception-based proposals, in the second half of the twentieth century, the focus of much research and theorizing in L2 phonology was on the production of sounds (see, e.g., Lado, 1957; Eckman, 1977, 1981; Major, 1987).

Increasingly, however, L2 phonologists have recognized the contribution of perception to "foreign accent," and a growing cross-linguistic speech perception literature has shown that L2 learners also have "perceptual foreign accents," i.e., the way they perceive the L2 is based on their L1 perceptual system (for a review of these studies, see Strange, 1995). As I will argue in this chapter, the origin of a foreign accent is the use of language-specific perceptual strategies that are entrenched in the learner and that cannot be avoided when encountering the sounds of a second language. Therefore, the chapter concentrates on critically discussing the issues and explanations regarding L2 perception as well as on the implications of such explanations for language teaching.

evidence for the priority of perception in phonological production

A growing body of literature supports the proposition that in both L1 and L2 phonological acquisition, perception precedes production chronologically and is a prerequisite for the development of productive control of individual sounds.[1] Within L2 phonology, a number of studies support the argument that in L2 development, perception precedes production and that a perceptual difficulty is likely to underlie the widely observed difficulty adults have in producing L2 sounds (Leather, 1999; Llisterri, 1995). Borden, Gerber, and Milsark (1983), for example, demonstrated that Korean learners' ability to identify and discriminate phonemes developed earlier and was more accurate than their ability to successfully produce L2 phonemes, thus suggesting that perceptual abilities might be a prerequisite for accurate production. Neufeld (1988) described a "phonological asymmetry" whereby learners were often much better able to perceptually detect sound errors than to avoid producing them. The same asymmetry was found for Chinese and German learners of English (Flege, 1993). In addition, a study of Brazilian and English learners of Canadian French (Rochet, 1995) established that L2 production errors were correlated with their identification errors in a perceptual task. Moreover, Barry (1989) and Grasseger (1991) reported that learners who had "well-established perceptual categories" also showed accurate production of L2 sounds, concluding that accurate perception needs to be established before accurate production takes place and, further, suggesting that perceptual tests can predict difficulties in L2 production.

Despite a large body of evidence establishing perception as the basis of production in a second language, other studies (e.g., Caramazza, Yeni-Komishian, Zurif, and Carbone, 1973; Flege and Eefting, 1987; Goto, 1971; Sheldon and Strange, 1982) have challenged the precedence of perception in L2 phonology and provided evidence that perceptual mastery does not necessarily precede, and may in fact lag behind, accurate production in L2 learners. However, these findings can be contested on the basis of a number of methodological shortcomings such as the controlled nature of the production tasks and the articulatory training undergone by the learners, which elicit highly monitored and unnatural L2 production, as well as the problematic nature of their data analyses. Furthermore, most of these studies report on perceptual findings that were conducted within a bilingual language setting, which, according to psycholinguistic evidence (Dijkstra, Grainger, and Van Heuven, 1999; Grosjean, 2001; Jared and Kroll, 2001), results in the activation of two languages and, consequently, in performance patterns intermediate between the speaker's L1 and L2 that would have not been found had the learners been in a monolingual L2 setting.

Given the number of studies showing the priority of perception in L2 phonology and the questionable nature of the studies purporting to provide counterevidence, the weight of the evidence suggests that in the acquisition of L2 phonology: (i) perception develops first and needs to be in place before production can develop, and (ii) the difficulty adult learners experience producing L2 sounds has a perceptual basis, such that incorrect perception leads to incorrect production. L2 phonologists should therefore increasingly incorporate perception into their models of learning, and give a central place to the assumption that the learner's ability to perceive non-native sounds plays a crucial role in the acquisition of L2 phonology.

learning to perceive sounds in a second language

As in learning the sounds of the mother tongue, learning to perceive sounds in a second language involves arriving at the appropriate number and type of sound categories and the appropriate mappings from the speech signal onto such categories. However, L2 acquisition differs from L1 acquisition in a number of respects, including:

(i) The staring point, or initial state, at the onset of learning a language;
(ii) The developmental constraints affecting mature learners; and
(iii) The cognitive interplay of two language systems during acquisition.

Each of these features of L2 acquisition needs to be considered in the description and explanation of L2 sound perception.

initial state

It has been widely observed that L2 sound perception is highly constrained by linguistic experience, i.e., by the sounds and perceptual processes of the native language, and it has been standard practice to describe, predict, and explain L2 perception by referring to the already-in-place L1. For instance, Trubetzkoy and Polivanov observed that L2 learners tend to associate the sounds of the new language to the sounds of their own L1 system, and they regarded this association as the cause of the learners' divergence from native speakers of the L2. In the field of second-language acquisition, the strong role of the L1 in L2 learning has been considered an important explanatory factor underlying L2 performance. The observed phenomena have typically been described and explained through the widely used concepts of *transfer* (or *interference*) and *cross-linguistic influence*, which, in general, refer to the fact that learners will make use of their L1 to cope with the L2 learning task. However, these terms, as they stand, do not specify how much or to what extent the learner will make use of the L1. Yet the assumed degree of transfer is crucial to the explanation of L2 acquisition.

In the realm of segmental phonology, a transfer explanation is especially attractive, given that there is nowhere else in the learner's L2 where L1 influence is more obvious. Yet the specific degree and nature of L1 transfer in L2 phonology remains, to date, a controversy, as acknowledged by Archibald and Young-Scholten (2003). Assumptions about the level of L1 transfer (namely, no transfer, partial transfer or full transfer) that best represents the initial state of L2 learners will influence the assumptions that can be made about the L2 learning task and L2 development. It is important to notice that the concept of transfer can have different meanings as suggested by Hammarberg (1997), so that it could refer to a learner "*strategy*" (either conscious or unconscious), to the "*process*" of transferring L1 knowledge onto the learning of L2 phenomena, or to the "*result*" of such a process. However, most L2 proposals seem to combine all three possible interpretations in their use of the concept of L1 transfer.

developmental constraints

The most common constraints that have been claimed to apply to L2 acquisition are *maturational constraints*, referring to physiological changes taking place – particularly, in the brain – as one matures. Most proponents of these constraints point at the fact that adults are not nearly as efficient language learners as children and explain the lack of efficiency in adults on biological and neurological grounds. For example, Penfield and Roberts (1959) claimed that an innate, *biological clock* for language learning allowed direct learning from the input until approximately the age of 9, with later ages of learning resulting in progressively poorer attainment levels. Lenneberg (1967) suggested that this loss of predisposition for language learning was due to the completion around puberty of *hemispheric lateralization*, the specialization in most humans of the two hemispheres of the brain for different functions. Lenneberg labeled the period between two years of age and puberty a *critical period* for language acquisition. This idea led him to formulate the *critical period hypothesis* (CPH), which claims that only before puberty can learners acquire a language automatically from mere exposure to the linguistic input around them. Other scholars have spoken of a *sensitive period or periods* (e.g. Long, 1990) for language acquisition.

Despite the obvious need for postulating age-related constraints on language acquisition, it seems controversial to claim that biological or neurological constraints act alone, as social, psychological, input, and language use factors are correlated with the observed decline in language acquisition capabilities. Moreover, there may be no categorical loss of language acquisition abilities at a specific age, but rather a continuous decrease in the probability of mastering an L2 at a native level of proficiency. This is in fact what is suggested in a recent review and proposal on maturational constraints in L2 acquisition by Hyltenstam and Abrahamsson (2003), who claim that there is a continuous *maturational period* which predicts that acquisition will be increasingly difficult with increasing maturation. However, they remain neutral with respect to the exact levels of L2 attainment that are possible after puberty because other non-maturational constraints can influence the end result (ibid., pp. 575–6).

Input constraints constitute an important type of non-maturational constraint, which is the linguistic evidence needed for language learning to occur. It seems that L1 learners need only *positive evidence*, i.e., exposure to speech around them (*ambient language*), in order to learn their native language, while L2 learners seem to need *negative evidence*, i.e., corrections or specific instruction, in order to learn a second language. In the area of input, other important issues need to be considered, such as the type of positive evidence given to an adult L2 learner, the relative use by and around the learner of L1 and L2, and the relative amount of exposure to the two languages – all of which may be crucial in determining level of proficiency in an L2.

Learnability constraints are at the core of the question of how L2 learners develop from an L1 transfer initial state to more closely approximate native-level knowledge and performance in a second language. Whether or not a native level of knowledge and performance are achieved, in order to learn a second language, some kind of a learning mechanism must be in place. Following a generativist perspective on language learning, some L2 researchers have proposed that L2 learning may or may not be guided by the set of principles or mechanisms that compose *universal grammar* (UG), which are universal, innate, and specific to the faculty of language. Several researchers have proposed that learners have *full access* to UG in L2 acquisition (see, e.g., Schwartz & Sprouse, 1996). However, as White (2003) rightly points out, the learner needs both a set of universal restrictions or principles defining possible grammars and a learning device. From a UG (*nativist* or *innatist*) perspective, such a device will function as a triggering or accessing device to select among the possible types of grammars.

In current phonological theory, learning devices have been proposed in the form of algorithms which analyze and modify the rules or constraints that constitute the developing grammar. An example of such a learning algorithm within a nativist or UG perspective is Tesar and Smolensky's (2000) *Constraint Demotion Algorithm*, which works within a description of phonological knowledge as developed in *Optimality Theory* (for an introduction, see Kager 1999). Alternatively, an *emergentist* account (for a review see MacWhinney, 1999) proposes that learning occurs in a bottom-up fashion, i.e., the learner's knowledge of an L2 changes with environmental input, by means of a general cognitive learning device, i.e., an algorithm or mechanism that is not specific to language.

the cognitive interplay of two language systems

If both L1 and L2 sound categories and perceptual processes are represented as knowledge in the learner's mind, the next natural question is how these two systems relate to each other. Presumably, they both belong to the linguistic faculty, but do L2 learners have a single perceptual system or two systems? The amount of separation or integration assumed between the L2 learner's phonological systems influences the level of perceptual proficiency that a learner can have in both languages. This type of constraint can be termed a *representational constraint*. Cook (2002) proposes that there are three logical possibilities for the representational status of two or more language systems. Figure 5.1 is an adapted version of a figure from Cook (2002, p. 11), which shows the possibilities of separated or connected L1 and L2 representations and includes an additional possibility of *mixed representations* as *merged* (or *integrated*, in Francis' terminology).

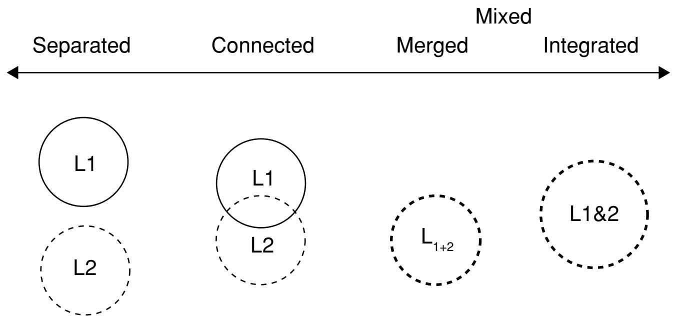

Figure 5.1 Possible cognitive status of sound categories and perceptual processes in L2 learners and bilingual speakers (adapted from Cook, 2002, p. 11)

It is a matter of debate which of these possibilities best describes the knowledge or performance of L2 and bilingual speakers; and we will see that assuming one of these possibilities crucially shapes the explanations of L2 perception discussed in the next section. In a *separated* systems view, L1 and L2 sound categories would be seen as belonging to distinct, autonomous systems. On the other hand, the *mixed* view advocates that L1 and L2 sound systems are, in fact, a single representational system. This perspective has, in turn, two possibilities – namely, *merged* or *integrated* systems. Merged representations imply no language differentiation, whereas integrated representations imply language specification within a single combined system. Within a less extreme perspective, such as the *connected* view, L1 and L2 representations are mostly distinct but may share some elements or properties, as shown by the intersection in the figure.

explaining L2 sound perception

In this section, I review six different models that aim to explain non-native or L2 sound perception, among which a new phonological proposal that incorporates phonetic and psycholinguistic insights. For each model, I critically discuss the view of perception, the proposal for the L2 learning task, the interpretation of the L2 learning constraints just reviewed, and the predictions and supporting evidence for the initial state and development over time.

the ontogeny model

Roy Major's Ontogeny Phylogeny Model (OPM; Major, 2001, 2002) attempts to describe the principles involved in the formation of L2 phonological systems, the change in L1 that results from exposure to L2, as well as language contact phenomena such as bilingualism and multilingualism. Major (2002, p. 88) states that the model is purposely not described in terms of the mechanisms of any linguistic framework so that its claims can survive beyond the life of any specific theory. Major explicitly states that the model makes very general claims without any details concerning specific phenomena such as fine-grained phonetics. He argues that this is a virtue of his model rather than a weakness because the model provides a macroscopic framework for testing individual phenomena. However, since the main input to the phenomenon of L2 perception that interests us here is the fine-grained phonetic information in the speech signal, it seems of importance to provide a more explicit proposal regarding the role of perception in the development of phonological competence.

In Major's model, one of the main tenants is the involvement of universal principles in the formation of phonological systems. It is proposed that L1 and L2 acquisition are aided by a set of innate linguistic universals which provide the L1 learner with a head start. These comprise: a universal grammar (UG), as well as learnability principles, markedness, underlying representations, rules, processes, constraints, and stylistic universals (all of them presumably specific to the faculty of language). For perception, it seems that markedness may not play a role, unless some auditory events could be described as more marked than others. If so, such events would perhaps be better described in terms of frequency and/or saliency. In general, representations as well as processes would need to be considered components of a possible explicit proposal for the knowledge underlying perception.

Although almost all of the supporting evidence comes from production data, the model also addresses L2 phonological competence for the perception of L2 sounds. Major's explanation for the finding of phoneme boundaries in bilingual perception that are intermediate between monolingual L1 and L2 boundaries, as reported in Caramazza et al. (1973) and in Williams (1977), provides a starting point for a proposal about L2 perception. According to Major, this intermediate performance in perception can be explained by the OPM's proposal of partially merged L1 and L2 systems (Major, 2002, p. 82): each of the bilingual's phonological systems is proposed to have a component of the other system (but see the Linguistic Perception model below).

With respect to L2 development, Major proposes that the development over time of the three components of the L2 phonological system – i.e., the L1 system, the L2 system, and the universal system (U) – will be different for different learning scenarios. It is proposed that L2 learners could be faced with three learning scenarios, namely "normal", "similar," and marked, depending on the nature of the linguistic phenomenon to be learned. If the L2 phenomena to be learned are "normal," i.e., dissimilar to L1 phenomena and not typologically rare, acquisition is guaranteed and L2 development will occur through:

(i) the declining influence over time of the L1 component;
(ii) an increase followed by a later decrease in influence of the U component over time; and
(iii) the increasing influence of the L2 component.

Relative to this "normal" scenario, L2 phenomena that are either "similar" to L1 phenomena or "marked," i.e., relatively rare linguistically (Major, 2002, p. 76), are predicted to be acquired more slowly. At the stage at which L2 "normal" phenomena would have been acquired, the learner's system for "similar" and "marked" phenomena would still be developing under the control of not only the L2 but also the L1 and U.

Despite the clear predictions for the different L2 scenarios, the learning mechanisms that trigger the decrease and increase in influence of the three components are not proposed, nor is there a proposal for the role of input in development. In addition, the "similar" scenario may not be more difficult or demand more time than the "normal" scenario, if acquisition of a typologically similar language item demands only the adjustment of already existing structures, while acquisition of a typologically distant language item implies the formation of new knowledge, which takes considerable time.

the phonological interference model

Unlike Major's theory-free and rather general proposal, Cynthia Brown's Phonological Interference Model (PIM; Brown, 1998) addresses speech perception through the formal means of phonological theory. The model aims to explain the origin of the influence of L1 phonology on the acquisition of L2 segments as well as to identify the level of phonological knowledge involved in such L1 influence. In the non-linear phonological framework of the model, that of *feature geometry* (Clements, 1985), it is assumed that phonemes have an internal structure composed of a hierarchy of phonological features which are contained in the phonological component of UG. In addition, Brown's model considers a two level process of mapping and categorization of speech sounds, in which the phonological structure mediates the perception of speech sounds, as shown in Figure 5.2.

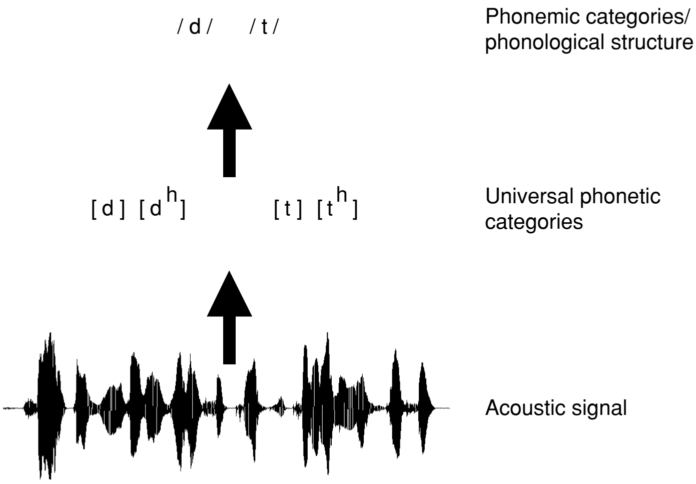

Figure 5.2 Brown's proposal for speech perception (adapted from Brown, 1998, p. 148)

As can be seen, Brown suggests that the acoustic signal is first broken down into universal phonetic categories by means of an auditory discrimination mapping (represented by the lower arrow). Then, these phonetic stimuli are processed at the second level (upper arrow), which consists of the speaker's feature geometry, or phonological structure. Within this proposal, the first mapping – that of auditory discrimination – is considered non-linguistic and non-cognitive, i.e., it is a general auditory process of discriminating sounds, whereas the second mapping is considered linguistic, i.e., it is language-specific.

With respect to the acquisition of perception, Brown and Matthews (1997) argue that the child starts out with a universal feature geometry, provided by UG, which is expanded over the course of acquisition until the adult feature geometry for the particular language is attained. It is argued that L1 development is guided by the particular dependency and constituency relations encoded in UG (Brown, 1998, p. 144) and by the child's detection of contrastive use of segments in the input. However, it is not clear how exactly the child would "detect" a contrast in the input so that additional structure can be incorporated into the developing phonological grammar. Regarding L2 perception, Brown argues that the L1 feature geometry, or phonological grammar, maps the L2 input onto existing L1 phonological categories and consequently eliminates the ability to perceive cues in the acoustic signal that could trigger L2 acquisition. Brown further proposes that if the distinguishing feature of a non-native contrast exists in the L1 grammar as a feature used for other L1 contrasts, then the L2 contrast will be perceivable and so will not be merged into the L1 category.

As an example, Brown compares the perception of English /r/ and /l/ by Chinese and Japanese learners. The English contrast is signalled by a difference in the place of articulation for /r/ but not /l/ as retroflex and thus coronal. Unlike Japanese, Chinese has a contrast that is also specified by the feature of retroflex versus non-retroflex (or coronal), i.e., alveolar versus retroflex sibilants. It is therefore predicted that Chinese but not Japanese learners should acquire the non-native (English) contrast of /r/ and /l/, based on the contrastive feature of retroflexion or coronality shared with the native language. Brown's results showed that indeed only Chinese learners were able to accurately discriminate the English contrast (Brown, 1998, pp. 155–70). However, Brown's results could still be interpreted as showing that Chinese learners map the two English consonants onto two different L1 categories, whereas the Japanese map them onto a single one. Additional experiments in the cross-language perception of monolingual Chinese and Japanese listeners would help to decide the issue.

Within Brown's model, no explicit proposal for the interplay between the L1 feature geometry and the developing L2 geometry has been made, and it is not clear whether L1 structures would be modified as they are redeployed to constitute L2 representations. In addition, Brown suggests that L2 phonologists should concentrate on non-native contrasts in which one of the members of the contrast is a phoneme in the learner's L1 because they provide a window to explaining how L1 features can enable L2 development. This would mean that the model could not account for the learning of new L2 features, such as the acquisition of vowel length categories in speakers of languages which do not distinguish between the duration of vowel sounds (e.g., Spanish, Polish, and Portuguese).

the perceptual assimilation model

Catherine Best's Perceptual Assimilation Model (PAM; Best, 1995) attempts to account for the observed performance in the perception of diverse non-native contrasts. Based on the frameworks of *Articulatory Phonology* (Browman and Goldstein 1989) and the *ecological approach* to speech perception, also called *direct realism* (Fowler, 1986), it is argued that an adult listener has no mental representations for perceiving speech, but rather directly seeks and extracts the patterns of articulatory gestures and gestural constellations from the speech signal. This direct realist, non-mentalist proposal contrasts with the mentalist and abstract speech perception proposals of the OPM and Brown's phonological interference model. Unlike Major's and Brown's model, the PAM explicitly proposes that perceptual learning in infants and children leads to language-specific perception, as the child automatically recognizes the pattern of articulatory gestures in the language environment. With respect to cross-language or non-native perception, the language-specific organization of articulatory events is proposed to lead to a lack of similar efficiency in finding familiar gestural patterns in non-native speech.

The model's central premise is that listeners tend to *assimilate* non-native sounds to the native sounds that they perceive as most similar. The model defines "perceptual similarity" in terms of dynamic articulatory information, i.e., in terms of the ways in which articulatory gestures shape the speech signal. Thus, regarding cross-language and L2 perception, the PAM proposes that accuracy in the discrimination of non-native sounds depends on the way they are assimilated to L1 sounds. It can be interpreted from this proposal that successful L2 sound discrimination is the basis for L2 perceptual success. With respect to cross-language perception, it is predicted that different degrees of sound discrimination will be found depending on which of the patterns of assimilation has been applied. Thus, for instance, if two foreign speech sounds are assimilated to two different native sounds, or phonemes, discrimination is predicted to be excellent, whereas if two sounds are assimilated to a single native category, discrimination will be poor.

The Perceptual Assimilation Model does not provide a clear mechanism for L2 development since its main aim is to predict and document cross-language perception, although Best and Strange (1992) suggest that exposure to L2 input (i.e., experience with the L2) may lead to the reorganization of perceptual assimilation patterns. However, neither the mechanism of such L2 reorganization nor its effect on L1 perception are addressed, and, crucially, a proposal for the extraction of the articulatory features for two languages is not considered.

the native language magnet model

Patricia Kuhl's Native Language Magnet model (NLM; Kuhl, 1991, 2000) aims at explaining the development of speech perception from infancy to adulthood. It is proposed that complex neural perceptual maps underlie the perception of auditory events, and that such neural mappings result in a set of abstract phonetic categories. Adult perception is seen as a language-specific process because infants learn the perceptual mappings of their ambient language (Kuhl, 2000, p. 11854). Kuhl's NLM proposes that, as a result of the emergence of neural maps to perceive the speech signal, perceptual representations are stored in memory, and these are the basis of the learner's development of sound production. Because perceptual mappings differ substantially for speakers of different languages, the perception of one's primary language is completely different from that required by other languages (Iverson and Kuhl, 1996). Kuhl (2000) emphasizes the language-specific nature of perception, further claiming that "no speaker of any language perceives acoustic reality; in each case, perception is altered in service of language" (p. 11852).

With respect to L1 acquisition, unlike the PAM, Kuhl's proposal considers the mechanisms underlying the learning of language-specific perception. It is proposed that the child engages in learning processes that lead to the emergence of a speech perception system and perceptual representations. Kuhl puts forward a body of evidence (e.g., Saffran, Aslin, and Newport, 1996) showing that infants acquire sophisticated information from the signal through the detection of the distributional and probabilistic properties of the ambient language as they seek to identify higher order units and categories. It is proposed that infants' perception becomes language-specific through the categorization, statistical processing, and resulting perceptual reorganization of the acoustic dimensions of speech that take place between the ages of 6 and 12 months. However, no formal proposal for the underlying mechanisms of these learning processes is offered.

With respect to L2 perception, the learning task within the NLM is to create a new perceptual system that can map the new language onto the appropriate phonetic categories. In Kuhl's view, the existence of an L1 language-specific perceptual filter will make learning an L2 difficult because later learning is constrained by the initial mental mappings that have shaped neural structure. That is, the model proposes that perceptual experience constraints future perceptual learning (e.g., L2 learning) independent of a strictly timed period. This argument gives an alternative explanation to "maturational constraints," i.e., the existence of a "critical period" for language learning, which have been commonly proposed to underlie the fact that adults do not learn languages as naturally and efficiently as children, as mentioned above. However, Kuhl (2000) also suggests that early in life, interference effects are minimal and two different mappings of the acoustic signal to different languages can be acquired, whereas when a second language is learned later in life (after puberty) separation between the two perceptual systems may be required to avoid interference. This difference has been shown in brain imaging studies demonstrating that only adult bilinguals who acquire both languages early in life activate overlapping regions of the brain when processing the two languages (Kim, Relkin, Lee, and Hirsch, 1997).

Despite its enlightening proposals, the NLM does not address the learning mechanism by which L2 experience can create new mappings appropriate for the L2. It may be reasonable to assume that L2 learning would occur through similar mechanisms to those found in L1. However, since Kuhl's proposal suggests that creation of new L2 mappings is more difficult after puberty and may require additional mechanisms (Kuhl, 2000, p. 11856), a more explicit proposal for L2 learning is needed. In addition, the model does not consider how the separation of perceptual mappings for two languages and the activation of overlapping regions of the brain are achieved, nor how these may be influenced by different levels of L2 proficiency.

the speech learning model

James Flege's Speech Learning Model (SLM) has been primarily concerned with ultimate attainment in L2 production (Flege, 1995, p. 238) and, more recently, with ultimate attainment in L2 perception (Flege, 2003). Flege has therefore concentrated on bilinguals who have spoken their L2 for many years and not on beginning learners. For him, sound perception is defined as the discerning of the phonetic features or properties in the signal that make it possible to identify the appropriate "positional-defined allophones" or "phonetic categories" of the language. In the SLM proposal, just as in Brown's model, there is no explicit proposal for how phonetic discerning or processing (i.e., the extraction of phonetic information for categorization) works. Neither does it propose how the degree of *perceived phonetic distance* can be measured, although the SLM suggests possibilities such as auditory, gestural, and phonological metrics for such perceived distance. In agreement with the PAM and the NLM models, Flege assumes that perception is language-specific and that therefore L2 perception problems do not have a general auditory basis (Flege, 1995, p. 266).

With respect to L1 acquisition, the model seems to assume the same learning processes and mechanisms proposed by the NLM model, namely, the ability to accurately perceive featural patterns in the input and to categorize a wide range of segments (Flege, 2003). However, no formal proposal for the mechanisms behind the learning of L1 perception is associated with the model, apart from the claim that perception is dominated by "equivalence classification," a mechanism that leads to the categorization of acoustically different tokens into the same abstract category (Flege, 1987, 1995). With respect to the proposal for L2 learning, the SLM has a strong perceptual component. Its basic tenant is that L2 production errors result from inaccurate L2 perceptual "targets," which, in turn, result from a failure to discern the phonetic differences between pairs of distinct L2 sounds or between non-identical L2 and L1 sounds. It is argued that learners relate L2 sounds to L1 positional allophones, and L2 perceptual failure occurs when the L1 phonological system filters out the distinctive features or properties of L2 sounds. However, the exact workings of such perceptual filtering are not discussed.

The SLM proposes that adults retain the capacity which infants and children make use of in acquiring their L1, including the learning of accurate perception of the properties of L2 speech sounds and the formation of new phonetic categories (see Flege and MacKay, 2004, for recent supporting evidence). L2 development is, however, constrained by four main factors: perceived cross-language similarity, age of arrival, L1 use, and the storage of L1 and L2 categories in a common phonological space. The first factor deals with the ability to discern the phonetic differences among L2 sounds or between L2 and L1 sounds depending on the degree of perceived cross-language phonetic similarity. The greater the perceived phonetic dissimilarity of an L2 sound from the closest L1 sound, the more likely it is that a new category will be created for an L2 sound (Flege, 2003). In support of this contention, Flege (1987) showed that native English learners of French could produce French /y/ more accurately that French /u/ because French /y/ is perceptually more distant from the closest English vowel than is the French /u/, which has a near (but not identical) counterpart in English /u/. However, no cross-language perceptual data was gathered to support Flege's interpretation of the L2 production data.

The second factor, age of arrival (AOA), predicts that native-like L2 perception will be more likely in learners who have an early (normally before puberty) AOA in the L2 community than in learners with a late AOA (after puberty) AOA (see Flege and MacKay, 2004, for recent supporting evidence). The state of development of L1 sound categories at the time of arrival in the L2 environment will influence the accuracy of L2 perception: the more developed the learner's L1 categories are, the more likely they are to block the formation of new categories for L2 sounds. With respect to the third factor, L1 use, it is predicted that learners who frequently use their L1 will be less likely than those learners who rarely use their L1 to attain a native level of L2 perception. Flege and colleagues (Flege and MacKay, 2004; Piske, MacKay, and Flege, 2001) found that learners who frequently used their L1, in contrast to those who infrequently used their L1, differed from native speakers in their perception of the L2.

Finally, the SLM proposes that L1 and L2 phonetic categories are represented cognitively in a common phonological space so that both systems will mutually influence one another. As a consequence, it is predicted that when a new phonetic category is established for an L2 sound that is close to an L1 sound, *dissimilation* will occur (Flege, 2002, 2003), causing the bilingual's L1 and L2 phonological categories and their L1 and L2 perception to be different from those of native speakers of each of the two languages (Flege, Schirru, and MacKay, 2003). Also, if a new category is not established for an L2 sound which differs audibly from the closest L1 sound, an experienced L2 learner will develop a "composite" (i.e., merged) category as a result of *assimilation* (Flege, 1987; MacKay, Flege, Piske, and Schirru, 2001). Flege (1995, 2002) argues that the principles of assimilation and dissimilation and the existence of a common L1-L2 phonological system may underlie Grosjean's (1999) claims that there can be no "perfect" bilingual, i.e., one who performs like a monolingual in both of their languages. Rather, since the bilingual's two systems are always both engaged at the same time, the "mixing" of L1 and L2 is inevitable. However, Grosjean's claims clearly refer to online performance rather than cognitive representation of the two languages. Therefore, concluding that bilinguals have a single cognitive representation for L1 and L2 phonetic systems seems rather extreme.

the linguistic perception model

The model of Linguistic Perception (LP) aims at describing, explaining, and predicting the knowledge underlying speech perception and the acquisition of this knowledge in learning a first or a second language. The LP model is embedded in the theoretical framework of *Functional Phonology* (Boersma, 1998), which claims that cognitive linguistic knowledge underlies speech perception. According to the LP model, the language-specific knowledge underlying speech perception comprises (i) a linguistic and grammatical processor, i.e., a *perception grammar*, which maps (i.e., categorizes) the variable and continuous acoustic signal; and (ii) perceptual representations or perceptual input, depicted in Figure 5.3. The perception grammar embraces psycholinguistics, phonetics, and phonology since it:

- incorporates "processing" into linguistic knowledge (*psycholinguistics*);
- contains "cue constraints" which are expressed in phonetic terms (*phonetics*); and

- expresses language-specific phenomena through formal linguistic means (*phonology*).

Within the LP model, the representations of sounds could vary in nature and degree of abstraction depending on the acoustic properties and feature combinations of auditory events in the language environment (Boersma, 1999). In addition, it is assumed that perception is a process mediating between (i) the acoustic-phonetic input in the outside world and (ii) the perceptual representation of language sounds, which, in turn, act as the input to (iii) the recognition system, which is responsible for accessing words in the mental lexicon, as shown in Figure 5.3.

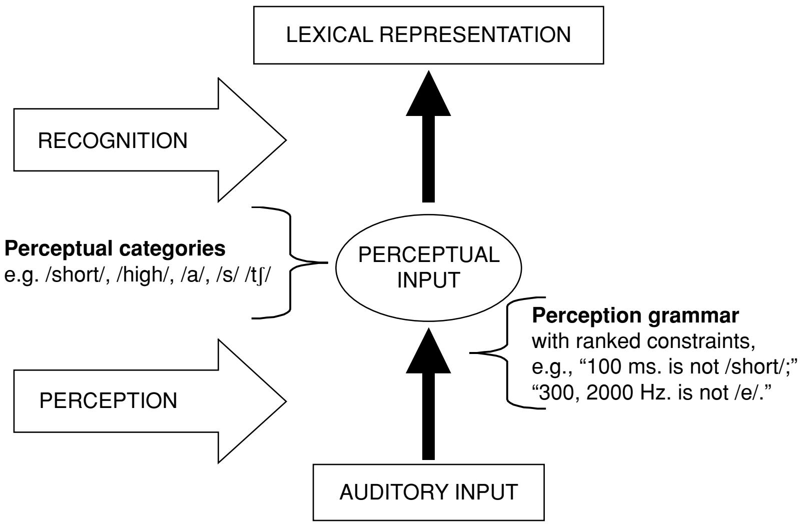

Figure 5.3 The Linguistic Perception model (Escudero 2005, p. 43)

According to the model, the acoustic signal is linguistically analyzed bottom-up without top-down application of lexical knowledge, which is compatible with many psycholinguistic models (e.g., Norris, 1994; models in McQueen, 2004). With respect to the workings of the perception grammar, it is proposed that an *optimal listener* will construct the perceptual categories that are most likely to have been intended by the speaker and thus will pay attention to the acoustic cues that are most reliable in the environment when perceiving sound segments (Escudero and Boersma, 2003). For example, Scottish English (SE) speakers pronounce the vowels /i/ and /ɪ/ with almost the same duration and with a very different vowel height, whereas Southern British English (SBE) speakers make a large duration distinction and a smaller height distinction between the two vowels (Escudero and Boersma, 2003). Therefore, the model predicts that SE will rely almost exclusively on height and hardly at all on duration when distinguishing the two vowels, whereas SBE listeners will rely more on duration and less on the spectral cue, which is confirmed by findings reported in Escudero (2001). According to Escudero and Boersma (2003), a perception grammar contains *cue constraints* that implement optimal perception and integrate multiple language-specific acoustic dimensions into phonological categories.

With respect to L1 acquisition, Boersma, Escudero, and Hayes (2003) extended the Linguistic Perception (LP) model to account for the developmental path that an infant follows when learning to perceive sound categories. It is assumed that sound categories and linguistic perception emerge from the learner's interaction with adult speakers and are not innately given to the newborn. Thus, a child needs to construct abstract representations of the sounds of the native language by creating a perception grammar, a process that is achieved through two learning mechanisms that are implemented sequentially by the Gradual Learning Algorithm (GLA; Boersma and Hayes, 2001). That is, the GLA acts initially as an identity matching and distributional learning device fed by the patterns and frequency distributions of the acoustic events in the linguistic input. This auditory-driven learning, based strictly on the patterns of sound in the ambient language, results in the "warping" of the infant's perceptual space so that F1 values of the acoustic input will be mapped onto the closest values of distributional peaks.[2] Second, once an abstract lexicon is in place in the learner's cognitive system, it can act as a reference system for achieving a more accurate perception grammar. This is achieved through the re-ranking of perception grammar constraints performed by the GLA.[3]

With respect to L2 learning, Escudero and Boersma (2004) and Escudero (2005) propose an L2 version of the Linguistic Perception model (L2LP) which involves the three[4] components of:

(i) *Full Copying* of the L1 perception grammar and lexical representations as the basis for a new perceptual system for L2;
(ii) *Full Access* to all mechanisms of L1 learning;
(iii) *Full Proficiency* in both L1 and L2 under conditions of high usage of both.

For the L2 initial state, it is proposed that the learner automatically creates a "copy" of the L1 perception grammar and the L1 representations when starting to learn an L2. This means that the L2 perception is handled from the beginning by a separate perceptual system which began as a copy of the L1 system but evolves with experience with the L2. With respect to L2 development, it is proposed that L2 learners have access to the same learning mechanisms, performed by the GLA, that were available for L1 learning – namely, auditory-guided category formation and lexicon-guided boundary shifting for phonological categories. With respect to ultimate attainment in the L2, it is proposed that native or native-like perception in a learner's two languages is possible because L1 and L2 constitute two separate systems (i.e., two separate sets of perceptual categories and two perception grammars). Both L2 development and L1 stability are predicted provided that the two languages are each used on a regular basis.

In support of Full Copying, Escudero (2001) showed that Spanish learners of Scottish English (SE) had native-like perception of SE /i/ and /ɪ/, while Spanish learners of Southern British English (SBE) used only duration differences to identify the SBE versions of these same vowels. These findings suggest that these learners reuse their Spanish perception grammar and therefore perceive the SE vowels as the two Spanish vowels /i/ and /e/ but perceive the SBE vowels as Spanish /i/, as proposed in Escudero (2001) and Escudero and Boersma (2004). The PAM describes these different L2 patterns as two-category and single-category assimilations, while the SLMs refers to them as "similar" sounds and "new" sounds, respectively. In addition to giving a definition for them, the L2LP model provides the mechanism and the formalization for the different developmental paths in learners faced with these two different scenarios. Furthermore, the model considers the case of Dutch learners of Spanish as a different (i.e., a third) L2 learning scenario (see Escudero, 2005, for a detailed description of the three learning scenarios for L2 sound perception).

Regarding Full Access and Full Proficiency, Escudero and Boersma (2002) showed that the /i/-/e/ category boundaries of Dutch learners of Spanish shift to a native-like location in advanced learners. In addition, Escudero (in progress) shows that in a "similar" scenario, advanced Canadian English learners of Canadian French shift their initial L1 category boundaries to match those of native listeners. These studies suggest that previous findings (see, e.g., Caramazza et al., 1973; and Flege and Eefting, 1987) of non-native performance in the same scenario can be disputed. Escudero and Boersma (2002) and Escudero (under review) also tested the L1 perception of the L2 learners and found that they had monolingual-like category boundaries. The reason why these two studies find Full Proficiency in the learners' L1 and L2 is because they controlled for "language modes" (Grosjean, 2001): the learners where conditioned to think that the only language they were hearing was either their L1 or their L2 but never both (see Escudero, 2005, for a discussion). Thus, the L2LP model's three hypotheses are born out because: (i) L1 and L2 constitute two separate systems given that the learner's L1 does not get affected (*Full Copying*); (ii) L2 learners develop through the same mechanisms observed in L1 acquisition (*Full Access*); and (iii) both L1 and L2 can be optimal (*Full Proficiency*).

the role of linguistic perception in teaching and training l2 phonology

It has been shown that training L2 listeners with tokens that have been acoustically manipulated in order to display exaggerated properties results in successful L2 perceptual processing (McClelland, Thomas, McCandliss, and Fiez, 1999). Furthermore, presenting L2 listeners with multiple instances of L2 sounds produced by different talkers and in different contexts also leads to effective perceptual training (Pisoni, Lively, and Logan, 1994). From this evidence, Kuhl (2000, p. 11855) argues that feedback and reinforcement are not necessary in learning to perceive L2 sounds, but rather that non-native listeners simply need the "right" kind of perceptual input, i.e., exaggerated acoustic cues, multiple instances of the same sound, and a mass listening experience – which are the features of child-directed speech (also called "motherese"). This suggestion is compatible with the Linguistic Perception model, which proposes that the GLA will act upon auditory inputs to gradually re-rank constraints; the more frequent an auditory input is, the faster the algorithm will reach the optimal perception of such input. Thus, L2 perception accuracy would benefit from perception training to enhance L2 input, both its acoustic properties and its frequency.

Another important skill that could be trained is "language control," the ability to activate one language system and inhibit the other based on linguistic and non-linguistic evidence. Kroll and Sunderman (2003, pp. 122–4) suggest that L2 teaching should incorporate a component of language activation and control, perhaps through the use of the L2 only and the avoidance of the L1 in the classroom, in order for beginning learners to modulate the cross-linguistic activation of the two languages in a manner similar to proficient bilinguals. The L2 version of the LP model is compatible with this training paradigm because it argues that L2 learners and bilinguals have two separate linguistic systems and that online activation of the two systems could lead to inaccurate L2 responses which do not represent the state of L2 development nor the stability of the L1 system. Therefore, it would be important to investigate whether listeners' performance accuracy could improve, if a language setting that inhibits more than one language is provided and if language control is learned, as seems to be suggested by the findings of Escudero and Boersma (2002) and Escudero (under review).

conclusion

The focus on production of much research and discussion in L2 phonology and language teaching has meant that until recently, the essential role of perception has been underappreciated. Research examining perception is leading to a greater understanding of the mechanisms underlying language learning and learning in general, as well as the nature of bilingualism. The L2LP model, which is consistent with a large body of research and consolidated theory in both L1 and L2 learning, differs from most previous approaches to modeling L2 phenomena in having perceptual processes at its core. In assuming the mechanisms of Full Copying and Full Access, and in describing them in formal terms, it goes considerably beyond previous work that attempted to explain L2 phonological data. Moreover, in assuming the possibility of Full Proficiency in both L1 and L2 as determined by usage factors, it provides new perspectives for understanding the causes of both "foreign accent" and the native or native-like behavior of highly bilingual speakers. In addition, its theoretical basis supports the learnability of phonology and offers directions for approaches to pedagogy to improve perception and to develop effective bilingual learning strategies. The L2LP model would thus appear to provide promising directions for current and future work in L2 phonology, and it is hoped that others in applied linguistics will continue to develop this model and its implications, theoretical as well as practical.

notes

1. Editor's note: see Chapter 2, this volume, for a review of the literature for L1 acquisition; see Chapter 10, this volume, for a discussion of speech perception in developmental phonological disorder.
2. This view is compatible with Kuhl's NLM as well as with the recent findings of distributional learning in infants (Maye, Werker, and Gerken, 2002).

3. These types of perceptual adjustments have been shown to occur developmentally in infants and children (Gerrits, 2001; Nittrouer and Miller, 1997).
4. The first two components of the model are an interpretation of the formal hypothesis of Full Transfer/Full Access as proposed by Schwartz and Sprouse (1996).

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