WHAT DETERMINES THE PERCEPTUAL DIFFICULTY ENCOUNTERED IN THE ACQUISITION OF NONNATIVE CONTRASTS?

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ABSTRACT

Of the several types of variables which interact to determine perceptual difficulty in the acquisition of nonnative contrasts, two types are selected for review: *Subject* variables, which define what the learner brings to the task of perceptually organizing nonnative contrasts, and *contrast* variables, which define what the learner is trying to organize perceptually.

INTRODUCTION

Probably anyone working in the field of L2 speech would agree that native language background is the one factor that contributes most importantly to perceptual difficulty in the acquisition of nonnative contrasts. Even though the evidence in support of this view is massive and unambiguous, such an answer would be simplistic, if not incorrect if provided without further qualification. This is so because L1 background is just one of many variables that may interact in complex ways to determine ease or difficulty in L2 speech perception. Polka [1] and Strange [2] have shown how the influence of this variable is mediated by, for instance, stimulus variables, which define *what* is selected for examination in L2 speech studies (e.g., type of contrast, acoustic cues to the contrast, phonetic contexts), and by task variables (including testing procedures), which define *how* the perception of nonnative contrasts is examined.

The organizational schema provided by Polka and Strange (orginally designed by Jenkins [3] to describe memory phenomena) will serve as a guideline to review what determines the perceptual difficulty encountered in the acquisition of nonnative contrasts. Because an overview of all variables and their interactions in L2 speech perception is beyond the scope of this contribution, it will focus on those types of variables that researchers *select* for study (i.e., subject and contrast variables), and largely ignore those variables that researchers can *manipulate* in studies of L2 speech perception (i.e., task variables). This focus is somewhat arbitrary and not intended as a comment on the relative importance of variables. The contributions of Strange and Jamieson emphasize the role of task variables (and their interactions with other variables) in L2 speech perception and in the training of nonnative contrasts. For detailed and comprehensive reviews of issues in L2 and cross-language speech perception, see [4].

SUBJECT VARIABLES

There are three subject variables whose roles in L2 speech perception have been studied and documented: L1 background (in great detail), L2 experience, and age of the learner (in somewhat lesser detail). Other variables must be involved, because large individual differences in the abilities of subjects to differentiate nonnative contrasts have frequently been observed even when subjects were homogeneous with respect to their L1 background, their L2 experience, and their age. However, the exact nature of these variables remains elusive. Some subject variables like gender, attitudes toward the L2 and the culture associated with the L2, or motivation to learn the L2, do not seem to contribute to the ability to differentiate nonnative contrasts. At present, the large individual differences especially among adult subjects can at best be attributed to some "talent" for language learning, but this cover term is clearly unsatisfactory because it is unknown what makes for a talented L2 perceiver. Large-scale correlational studies of L2 speech perception in adults are called for to identify which as yet unknown variables may play a role in creating the kind of outliers found in almost any L2 speech study, i.e., nonnative listeners with excellent perceptual abilities despite limited L2 experience at the one end and nonnative listeneners who seem to be immune to L2 experience at the other end.

L1 Background

Polivanov [5] was probably the first to acknowledge in detail the important role of L1 background in L2 speech perception. Polivanov does not clearly state the empirical bases for his observations; it appears that they are derived from nonnative speakers' productions (which are not a good indicator of perceptual problems, s. Llisterri, this volume). Still, Polivanov's insights anticipate the results of experimental work carried out almost 40 years later. His remarks on L1-dependent "thresholds of differentiation" (i.e., category boundaries) for initial stops differing in voice onset time (VOT) foresee one of the main results of Lisker & Abramson's [6] seminal study, in which listeners from three different language backgrounds (English, Spanish, and Thai) identified stimuli from a synthetic VOT-continuum in L1-specific ways: "the same pronunciation of the stop consonant ... will be relegated to different members of the given pair of phonemes in each of the ... given language consciousnesses". It is these different language consciousnesses, or, as one would put it today, language-specific ways to organize phonetic distinctions into phonologically relevant contrasts, that are a major source of perceptual difficulty in the acquisition of nonnative contrasts, as in Polivanov's example of Russian prevoiced /b/ and voiceless unaspirated /p/, which "seem completely identical for the Chinese perception".

A very large number of studies conducted over the past 25 years have documented that difficulty in the perception of nonnative contrasts is systematically related to the perceptual differentiation of phonetic contrasts in the L1. The influence of L1 background on L2 perception, however, is not all-pervasive. Depending on the nature of the variables that irteract with L1 background, its influence on the perception of nonnative contrasts may be reduced by specific L2 experience [7], it may be stronger for certain types of contrasts than for others [8], it can be amplified or attenuated through experimenters' choice among task variables [9], or it may even be completely absent for certain types of cues to the nonnative contrasts [10] and for nonnative contrasts that are nonassimilable to L1 contrasts [11].

L2 Experience

Studies which compared adult learners with varying amounts of L2 conversational experience for their ability to differentiate L2 contrasts indicate that L2 experience may induce L2 learners to reorganize their "linguistic consciousness". For instance, in a study that examined how two groups of L1 Japanese learners differing in English language experience identified and discriminated stimuli from a synthetic English /r/-/l/ continuum, MacKain et al. [7] reported that Japanese learners with extensive English experience had much steeper identification functions and higher and narrower discrimination peaks than L1 Japanese learners with little English language experience. However, the experienced Japanese learners of English still performed less accurately than native English listeners on discrimination of the English /r/-/l/ contrast (see also [12]).

In another case, Bohn & Flege [13] reported that L1 German learners of English, who had spent less than 1 year in the USA, differentiated synthetic stimuli from an English /ɛ/-/æ/ continuum by almost exclusively using temporal cues and ignoring spectral cues. Their perception of this L2 contrast was quite unlike a group of L1 English listeners, who relied almost exclusively on spectral cues to differentiate the /ɛ/-/æ/ contrast. Evidence of perceptual learning through L2 experience was provided by a group of German learners of English with extensive conversational L2 experience (>5 years of residence in the USA), who differentiated this contrast in a way that resembled native English listeners' perception in that they relied more on spectral than temporal cues.

However, as in other studies that examined the influence of L2 experience on the perception of L2 contrasts [7, 12], Bohn & Flege also found that several years of experience do not guarantee that L2 learners' perception will become completely native-like. The perception of

the /ɛ/-/æ/ contrast by the experienced German group was more English-like than that of the inexperienced German group, but it still differed from the native English listeners.

Why is it that even after years of experience, adult L2 learners' perception of L2 contrasts remains less accurate than the perception of native listeners? One factor that seems to contribute to perceptual difficulty despite massive L2 experience is the relation of L2 contrasts to native categories (s. also below). A number of studies carried out by Flege and his collaborators (summarized and reviewed in [14]) suggest that L2 experience is most likely to lead to perceptual learning if at least one of the members of the L2 contrast is "new", i.e., has no easily identifiable counterpart in the learner's L1, as English /æ/ for L1 German learners. If, however, both members of the L2 contrast are easily assimilable to counterparts in the L1 that are similar, but not identical to the members of the L2 contrasts, perceptual learning seems to be blocked.

This would explain, for instance, why experienced German learners of English in the Bohn & Flege study [13] did not differ from the inexperienced German learners in their use of both spectral and temporal cues to differentiate synthetic stimuli from an English /i/-/ɪ/ continuum. The reliance on both cues to differentiate the English /i/-/ɪ/ contrast seems to be a perceptual strategy transferred from differentiating German /i/-/ɪ/. Despite massive L2 experience, the experienced German learners did not even start to differentiate the English /i/-/ɪ/ contrast in a way that approximated the native English listeneners' perceptual strategy, which was characterized by the predominant use of spectral cues.

For easily assimilable L2 contrasts whose members have similar counterparts in the learners' L1, L2 experience in the form of conversational experience does not seem to induce perceptual learning. Still, training studies have yet to show whether this particular relation of L2 contrasts to native categories does indeed immunize L2 learners' perceptual learning abilities from structured L2 experience.

An important methodological problem in studying the role of L2 experience concerns the quantification of that variable, which is prerequisite to an adequate assessment of the quality and quantity of L2 input needed to induce perceptual learning. As a first approximation, length of residence in the L2 community would seem to be a valid measure of L2 experience. However, even learner groups with largely homogeneous social characteristics may differ considerably both in the amount of processible input they receive over a given time period and perhaps even in the quality of L2 input (e.g., authentic vs. foreign-accented). An obvious way to approach this problem is to collect detailed language background data from subjects, but how is one to weight different qualities and quantities of L2 input, e.g., amount of L2 mixed-dialect input at the workplace vs. foreign-accented input at home?

These methodological problems must be clarified before one can address the important question of what the limits of ultimate attainment are in adult L2 speech learning. For expample, Bohn & Flege [13] simply assumed that English language experience would be minimal for L2 learners who had spent an average six months in the USA, and that perceptual learning had reached its ultimate level for those L1 German learners who had spent an average 7 years in the USA. This assumption was justified to a large extent, for the two German groups differed clearly in how they perceived the English /ɛ/-/æ/ contrast. (They differed even more clearly in how they differentiated that contrast in production [15].)

Even though common sense would predict that the experienced learners in the Bohn & Flege [13] study had probably reached their level of ultimate attainment, L2 speech research still needs to address the questions of what amount of L2 experience enables perceptual learning and when this learning comes to a halt despite continued exposure to the L2. Studies of L2 learning in such diverse areas as speech production [16] and morphology and syntax [17] suggest that after a maximum of 5 years of L2 experience, adult L2 learners have reached their ultimate level of attainment.

One very interesting finding that has received relatively little attention

concerns the long-term effects of early experience. Tees & Werker [18] reported that subjects who had been exposed to Hindi in early childhood (but who had no contact with Hindi after age 2) could discriminate two Hindi stop contrasts (retroflex vs. dental and dental voiceless aspirated vs. voiced aspirated), whereas L1 English listeners with no Hindi experience performed very poorly. This suggests that early experience with a specific contrast helps maintain perceptual abilities necessary for discrimination of that contrast until much later in life even without intervening specific experience. In a study which examined the perception of a Salish place of articulation contrast (velar vs. uvular) in voiceless glottalized stops, Polka [19] reported that even though neither English nor Farsi has that specific Salish contrast, early Farsi bilinguals apparently benefited from nonspecific early experience with the Farsi velar vs. uvular contrast for voiced stops. This suggests that specific early experience may not be necessary to maintain accurate perception. Rather, broad experience with features employed to differentiate a contrast may be sufficient to maintain perceptual abilities.

Age

The most influential hypothesis on the age factor in language acquisition is Lenneberg's [20] Critical Period Hypothesis, which states that successful acquisition is possible only between the ages of (roughly) 2 and 12 years. This was hypothesized to be so primarily because only the prepubescent brain was supposed to have the plasticity needed to allocate new language functions. Even though research conducted over the past 25 years has shown that the original assumptions regarding the time frame, its biological basis, and the abruptness of the boundaries of the alleged critical period for language learning are wrong [16, 17, 21], the fact remains that children typically acquire languages with apparent ease and successfully, whereas language learning in adults is typically more effortful and, in the end, less successful.

These age-dependent differences are especially marked in speech perception. Research on infants' abilities to discriminate speech contrasts has shown that young infants (< six months of age) discriminate consonant contrasts in a categorical manner, no matter whether they had been exposed to the relevant contrasts in their ambient language [22]. The fact that young infants are not language-specific perceivers whereas adults are, lead to the assumption that adults' perceptual difficulties with nonnative contrasts were due to a loss of perceptual abilities with regard to those phonetic differences that are not phonologically distinctive in their L1.

Two types of evidence have shown that the inferior perceptual abilities of adults (as compared to infants) do not result from an atrophy of sensory abilities. First, Werker & Logan [23] showed that adults can discriminate acoustic differences that define nonnative contrasts if task variables are manipulated in a way that enables adult listeners to attend to stimuli in a general auditory rather than a specific phonetic mode. However, if adults process speech sounds in the specific phonetic mode of perception (which they normally do), they do not attend to acoustic detail that is irrelevant to category membership in the L1. It appears that L1 experience leads native listeners to focus on just those acoustic properties of speech sounds that define category membership in the L1. This selective attention is highly overlearned and indispensable for accurate and efficient perception of speech sounds in the L1, but it may entail, inattention to those acoustic dimensions and patterns that nonnative languages may employ to classify phonetic segments into functional categories.

Another type of evidence indicating that adult listeners' difficulties with nonnative contrasts are attentional in nature comes from studies which report successful learning for at least some nonnative listeners. For instance, Bohn & Flege [13] found that a sizeable proportion of experienced German learners had learned to differentiate the new English /ɛ/-/æ/ contrast in an English-like manner. No such evidence of perceptual learning was found for the similar English /i/-/ɪ/ contrast. The implication that learnability is a function of the relation of L2 contrasts to nonnative categories is incompatible with the view that perceptual problems of adults are due to sensory loss, for why

should this loss affect similar sounds of the L2, but not new ones?

CONTRAST VARIABLES

Studies which examined the perception of two or more contrasts by the same listeners using identical procedures typically report that nonnative contrasts differ both in the amount of difficulty they present initially and in their learnability [8, 11, 12, 13, 19, 24, 25]. What accounts for this nonuniformity? Is it the inherent salience of acoustic parameters that signal different types of contrasts, or is it L1 experience with certain contrasts (and features used to differentiate those contrasts) and the relation of L2 contrasts to L1 categories that determines relative difficulty? These questions will be addressed by looking at types of contrasts and types of cues for which differences in perceptual difficulty have or have not been reported.

Type of contrast

Different types of contrasts have received different amounts of attention in cross-language and L2 studies. Most studies have examined consonant contrasts, in particular the voicing contrasts in syllable-initial stops [6, 18, 22] and place-of-articulation contrasts [7, 8, 12, 19, 23]. With a few exceptions (e.g., [26]), nonnative vowel perception has only recently received detailed attention [10, 13, 25, 27, 28, 29].

Studies which compared nonnative perception of voicing and place-of-articulation contrasts have found that nonnative place contrasts are generally more difficult to differentiate and more resistant to learning than voicing contrasts. For instance, Tees & Werker [18] showed that a Hindi voicing contrast (voiceless aspirated vs. voiced aspirated) was easier to learn for L1 English subjects than a Hindi place contrast (retroflex vs. dental). One interpretation of this and of similar findings is that the voicing contrast is psychophysically more distinctive or robust than the complex spectral and temporal changes that signal place contrasts [30]. Alternatively, nonspecific L1 experience with the voicing contrast as opposed to lack of experience with place contrasts examined may account for these findings [31]. This may explain, for instance, why Jamieson & Morosan [32] found that L1 French listeners, whose L1 employs the voicing contrast in fricatives, learned to differentiate the English /θ/-/ð/ contrast rapidly, and why L1 Japanese learners have massive and persistant learning problems with English /r/-/l/ [7, 12, 31].

Nonnative perception of English /r/-/l/ also serves to illustrate a point that has only recently been studied in detail, namley, the phonetic and phonotactic context in which nonnative speech contrasts occur [8, 19]. For instance, studies by Pisoni and his collaborators (summarized in [33]) have shown how position (e.g., pre- vs. postvocalic) influences L1 Japanese listeners' ability to differentiate English /r/-/l/. In the postvocalic position, perception is much more accurate (because of the coloring of the preceding vowel) than in the prevocalic position. Phonetic context effects on nonnative vowel perception have recently been examined by Strange [34], who reported that the goodness of fit and the categorization of German /Y/ into English front or back vowel categories depended on the consonantal context in which /Y/ occurred. The results of the Strange [34] study suggest that reference to formant targets is not sufficient to explain patterns of interlingual identification for vowels.

In the discussion of the L1 background factor, it was mentioned that perceptual problems with consonant contrasts are largely predictable from the way in which the L1 classifies phonetic distinctions into functional categories. It is not clear whether this is also true of L2 vowel contrast perception. Rochet [28] reported that L1 speakers of English, of Portuguese, and of French labeled a high vowel continuum (/i/-/y/-/u/) in ways that directly reflected how their respective L1s use and segment that part of the vowel space. However, studies of vowel discrimination suggest that L2 vowel perception is less influenced by L1 background than L2 consonant perception. For instance, Stevens et al. [26] found that L1 background had little effect on how L1 Swedish and L1 English listeners discriminated isolated steady-state vowels. In addition, high discrimination levels for naturally produced nonnative vowels have been reported by Polka & Werker [27].

Clear differences in the ability to discriminate nonnative vowels have been observed in infant speech perception. In a cross-language study that examined the discrimination of the German-only contrast /u/-/y/ and the English-only contrast /ɛ/-/æ/ by English-learning and by German-learning infants in two age groups each (6-8 and 10-12 months), Polka & Bohn [35] found that the /u/-/y/ contrast was more discriminable for both language groups (and both age groups) than the /ɛ/-/æ/ contrast. For this case, at least, differences in the ability to perceive vowel contrasts seem to have a universal (e.g., psychophysical) rather than an experiential (i.e., L1 background) basis. Further research is underway to examine whether certain areas of the vowel space or certain acoustic dimensions that underlie vowel contrasts are more discriminable than others both in early infancy and adulthood [36].

Type of cue

Few studies have directly addressed the question of whether perceptual and learning problems are related to the nonnative-like use of cues that signal a contrast [10, 13, 37, 38, 39]. These studies typically employ the trading relations paradigm, in which redundant acoustic dimensions underlying a contrast are varied orthogonally in synthetic speech stimuli. For instance, Yamada & Tohkura [37] found that Japanese learners' perceptual problems with the English /r/-/l/ contrast are related to their use of the F2 transition cue, whereas native American English listeners predominantly use F3 onset frequency to differentiate /r/-/l/.

A set of studies examining trading relations in nonnative vowel perception was conducted by Flege and Bohn (summarized in part in [10]). L1 speakers of German, of Spanish, and of Mandarin who had limited L2 English experience were tested for their use of temporal vs. spectral cues in differentiating new English vowel contrasts (/ɛ/-/æ/ for L1 Germans, /i/-/I/ for L1 Spanish and Mandarin speakers). Native English listeners differentiated these contrasts almost exclusively on the basis of spectral differences, but the nonnative listeners responded primarily on the basis of duration rather than spectral differences. This perceptual strategy of inexperienced L2 listeners could not be attributed to the use of the duration cue in their respective L1s, for neither Mandarin nor Spanish differentiate vowels on the basis of duration. Bohn [10] hypothesized that the use of the duration cue to differentiate a new vowel contrast is an L1-independent, universal strategy that is applied whenever L1 experience has desensitized nonnative listeners to spectral differences in areas of the vowel space that are underexploited by the L1.

Further studies are needed to help determine which of the multiple cues signaling a nonnative contrast contribute to perceptual and learning problems, and what makes nonnative listener use cues that are not used by native listeners. An area of research that has only recently started to attract attention is the use and integration of visual cues in nonnative speech perception. In a study that examined cross-language influences on bimodal speech perception, Werker et al. [40] found an increasing relation between L2 English experience and the extent to which L1 French listeners integrated visual and acoustic cues. Training studies might profit from directing L2 learners' attention not just to critical acoustic cues, but also to visual cues which learners can exploit in face-to-face communication (e.g., visibility of the tongue tip in interdentals, which are acoustically very similar to labiodentals).

CONCLUSION

This review indicates that there is no simple answer to the question of what determines perceptual difficulty in the acquisition of nonnative contrasts. Two models have been proposed which pay tribute to the complex interactions of subject and contrast variables in L2 and cross-language perception. Both Best's [11, 29] Perceptual Assimilation Model (PAM) and Flege's [14] Speech Learning Model (SLM) attempt to predict perceptual difficulty on the basis of the perceived relation of nonnative speech sounds (i.e., contrast variables) to L1 categories (i.e., the L1 background variable). The models complement each other in that the SLM, which focuses on individual segments rather than contrasts, is a developmental model that

incorporates the subject variables L2 experience and age, whereas PAM is a model of cross-language perception that tries to account for listeners' initial difficulty with nonnative contrasts.

Flege's SLM classifies the relation between L1 and L2 sounds along a continuum ranging from "identical" over "similar" to "new". New sounds of the L2 are hypothesized to be sufficiently dissimilar from any L1 sound so that L2 learners will eventually discern the difference and establish a new perceptual category. Similar sounds, however, are classified by L2 learners as equivalent to their L1 counterparts, which blocks category formation.

According to Best's PAM, nonnative contrasts are assimilated to L1 categories either as good exemplars, acceptable exemplars, or notably deviant exemplars of the L1 category. In addition, nonnative categories that are very discrepant from any L1 sound are not assimilated into native categories at all, they are heard instead as some sort of nonspeech sound. Difficulty in the perception of nonnative contrasts is predicted by these different assimilation patterns.

Both models have been tested in several studies (reviewed in [14] and [29]) and the results have been, in general, quite supportive the models' predictions (but see [14]). One important problem which both Best and Flege acknowledge is that the predictive powers of both PAM and SLM rest upon the perceived phonetic similarity of L1 and L2 speech sounds. Progress in L2 speech perception research, which has come a long way since Polivanov [5], depends to a large extent upon success in developing objective means for predicting patterns of assimilation and interlingual identification.

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