

Vowel discrimination in early bilinguals and the perceptual magnet effect

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1. INTRODUCTION

It is a well-accepted fact that phonetic categories have an internal structure. Specifically, it has been proposed that they are internally organized around prototypical values. This notion holds that some physical realizations of a certain phoneme are more representative of a phonetic category (i.e. they are the center of the category or very close to it), while others are considered progressively poorer exemplars, the more they differ from the prototype. These prototypical values vary from language to language, that is, different languages have different physical realizations as prototypes. It has also been shown that the perception of speech sounds is strongly influenced by this internal structure of maternal language categories. Specifically, it has been shown that stimuli around good exemplars of a phonetic category are more difficult to discriminate than stimuli around bad exemplars from equally similar sounds. We are referring to the perceptual magnet effect as it is established in Kuhl's (1991) Native Language Magnet Theory of Speech Perception. This effect seems to be restricted to phonemes present in the maternal language, and is acquired in the first months of life (around 6 months of age). From exposure to the native language, infants form prototypes, that is, they have stored representations of native-language phonetic categories which highlight the best exemplars or prototypes. These prototypes function as perceptual magnets reducing the perceptual distance between certain vowel stimuli.

From the NLM proposal some predictions can be made relative to the acquisition and representation of L2 sound categories. In a recent work by Iverson and Kuhl (1995), the authors suggest that adults learning a L2 would find it difficult to perceive a phonetic contrast from a new language when the sounds are proximate to a native-language prototype. So, the process that assists infants in the acquisition of phonology seems to adversely affect adults subsequent ability to perceive L2 contrasts. On the other hand, it has also been suggested that if exposure to an L2 takes place before a critical age (before or around age 6), this second language will be learned quite well, achieving a native-like competence, that is, with little or no trace of accent from L1 phonology (see Flege, 1992, for a review). Some studies seem to indicate that young L2 learners achieve good pronunciation of L2 sounds because they have been able to form separate phonetic categories for the corresponding L1 and L2 sounds and category boundaries for them seem to have the same locations as the ones found for monolingual speakers; in the case of bilinguals and also less successful L2 learners, it has been claimed that they seem to develop a single compromise boundary, intermediate between L1 and L2 target values but that matches neither one nor the other. Thus, for bilinguals and young learners a certain level of plasticity

has been suggested in the ability to form new native-like categories for new sounds or in the capacity to modify previously established values.

The present paper investigates the plasticity issue by analyzing the existence of the perceptual magnet effect in highly proficient Spanish-Catalan bilinguals born in monolingual families and who have started exposure to an L2 during preschool years (4-6 years) and formal learning of L2 from primary school on. We call them «early bilinguals» as opposed to simultaneous bilinguals or late learners. They have received bilingual education, tuition in both languages, and they have become highly proficient in both Spanish and Catalan by the end of secondary school. More specifically, our goal is to describe Catalan-Spanish bilinguals perception of vowels corresponding to three different categories: the two Catalan high mid and low mid front vowels (/e/ and /ɛ/ respectively) and the Spanish mid front vowel (/e/), which does not match exactly the corresponding high mid Catalan vowel.

If we consider that prototypes are not only acquired early in life, but remain relatively unchanged even when speakers are extensively exposed to new phonetic categories also during the first years of life, one should expect to find only magnet effects for the maternal language or, at least, stronger prototype effects for this language than for a second language. If, on the contrary, the process of learning phonetic categories can be modified by the presence of another language early in life (before or around 6), the prototypes of the maternal language could be 'expanded' to include the second language ones or, if these new sounds are different enough in terms of perceptual/gestural distance, a third alternative is also possible, that is, subjects could eventually develop two separate vowel systems for the two languages, showing similar prototype effects in each of the two languages.

We will briefly summarize results from a series of experiments aimed at: a) finding support for the existence of prototypical exemplars and the characteristic internal structure of speech categories; b) analyzing the perceptual consequences of this internal structure in a discrimination task so that evidence of the magnet effect is found and c) analyzing the extension of this magnet effect (plasticity issue) by comparing early bilingual adults' responses to L1 and L2 vowel prototypes, in the special case in which prototypes in one language are probably bad exemplars in the other.

2. EXPERIMENT 1: GOODNESS OF FIT JUDGEMENTS

Three groups of eight bilingual subjects (two Catalan-dominant and one Spanish-dominant, according to their maternal language) were required to give goodness of fit judgments to establish the prototypes corresponding to the three different vowel categories mentioned above (Catalan /e/: F1= 405 Hz, F2=2054 Hz; Catalan /ɛ/: F1=641 Hz, F2= 1948 Hz; Spanish /e/: F1=474 Hz, F2= 2054 Hz) .

Following the procedure described in Kuhl (1991), 32 variants of these vowels were synthesized, corresponding to a regular distribution of the stimuli forming four orbits and eight vectors around the center vowel for each category. Variants were obtained by modifying either F1, F2 or both at the same time. Subjects were tested individually. They had to rate on a seven-point scale each of the stimuli presented through a loudspeaker. They listened to and rated 165 stimuli, that is, the center vowel and each of the 32 variants five times.

In general terms, and although the ratings for the tested prototypes were not extremely high (5.3, 5.8 and 5.3 for Catalan /e/, Catalan /ɛ/ and Spanish /e/, respectively), data showed the expected distribution of goodness ratings, with decreasing values from the center to the

extremes of the eight vectors, except in the case of the stimuli around the Catalan /e/. Given this particular result which suggests difficulties in finding an appropriate prototypical value for this vowel, it was decided to run the discrimination tests with the other two vowels: Catalan /ɛ/ and Spanish /e/.

3. EXPERIMENTS 2A AND 2B: VOWEL DISCRIMINATION

Different groups of bilinguals were asked to perform a discrimination task with materials in their maternal language and in their second language. A new set of synthetic vowels around a poor exemplar of the /e/ vowel (F1=405 Hz, F2=1810 Hz) formed the Non-Prototypical material for which no magnet effect should be found.

Each subject was exposed to the 32 variants of one vowel. They were instructed to press a button when a vowel (the referent), which was repeated continuously every second, changed. Subjects received no feed-back for their performance.

Responses for each language group of subjects and for L1 and L2 vowel stimuli were analyzed separately. For the L1 vowel discrimination task, the pattern of results showed quite similar effects in the Catalan and Spanish subjects. The distance factor was significant for both groups, and the interaction found between the P and NP conditions can be considered as evidence that subjects generalize more when they are comparing changes against the prototypical than against the non prototypical referent. Therefore, these results can be considered to support the existence of magnet effects for Catalan and Spanish subjects when listening to vowels of their own maternal language.

For the L2 vowel discrimination task, a significant interaction was found, for both types of bilinguals, between the maternal language materials and the second language materials (as well as the lack of interaction between the second language materials and the non prototypical set). Thus, evidence was obtained suggesting that these early bilingual subjects do not show the magnet effect for materials that do not belong to their maternal language. As mentioned before, these results seem to indicate that certain constraints exist on the plasticity or modifiability in the internal organization of the vowel space. The general idea suggested here is that individuals form prototypes for L1 that do not alter after exposure to an L2, even though this exposure is quite early in time, slightly before the critical age limit which is considered to be around 6 years of age. This holds true for sound categories which are similar but not identical in L1-L2 comparisons. It is not possible to know whether new prototypes could eventually be built if the sounds in L2 were located in a non-compromised vowel space.

4. EXPERIMENT 3: WITHIN SUBJECTS DESIGN

A third experiment was run using a within subjects design, so that if any effect were observed, it could not be attributed to subjects' differences. The experimental procedure was modified accordingly so that a bias-free measure, such as *d'*, could be calculated. Seven tokens from each of the three vowel sets were used, they included P and NP values, and stimuli of the first three orbits on a single vector through the acoustic space.

On each trial, subjects heard two stimuli with a 250 ms ISI. They were instructed to press a button if they thought the stimuli were different. Each subject completed four blocks of trials (corresponding to Catalan-/ɛ/, Spanish-/e/ and twice the NP). Measures of *d'* were calculated for

each subject, each material and each distance from the center vowel (interval). Results indicated that subjects had reduced discriminability for vowel tokens near the prototypical value of a vowel in their maternal language than for vowel tokens near a non-prototypical exemplar and, what is more interesting to the present study, this reduced discriminability did not generalize to vowel tokens near the prototypical vowel for the corresponding L2 category. Therefore, we replicated the pattern of data of the previous experiments using a bias-free measure.

5. CONCLUSION

Taken together, the results reveal that bilinguals only show the perceptual magnet effect for good exemplars of their maternal language, not for good exemplars of their second language. These findings favor the hypothesis that phonetic categories are not only acquired early in life, but that they remain quite unchanged, in spite of the strong presence of similar phonetic categories from other languages in the environment.

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