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Perceptual assimilation of Dutch vowels by Peruvian Spanish listeners

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Abstract: Many cross-language and L2 speech perception studies have been conducted on English sounds and a limited number of speakers or synthetic tokens have been used for auditory stimuli. The Spanish listeners of the present study were presented with natural tokens of Dutch vowels produced by males and females selected from the corpus reported in Adank *et al.* [(2004). J. Acoust. Soc. Am. **116**, 1729–1738]. The results show that single category assimilations are common and that certain Dutch vowels frequently assimilate to Spanish diphthongs. Predictions are made for Spanish learners' initial stage in the acquisition of the Dutch vowel system.

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1. Introduction

The present study investigates the cross-language categorization of Dutch vowels by 40 naïve Spanish listeners in order to make predictions on subsequent second-language (L2) development. Cross-language and L2 perception studies have often concentrated on naïve listeners or learners of English who have native languages (L1) with small vowel inventories (e.g., for Spanish: Escudero and Chládková, 2010; Fox *et al.*, 1995; for Japanese and Greek: Lengeris, 2009; for Mandarin: Jia *et al.*, 2006; for Russian: Gilichinskaya and Strange, 2010). Other languages with vowel inventories of a comparable size to English, such as Dutch, may also pose perceptual problems to learners whose native language has a relatively small vowel inventory due to the fact that there are fewer L1 vowel categories to which L2 vowels can be assimilated. While the vowel inventories of Dutch and English exhibit some similarities, it remains unclear whether perceptual problems encountered by Spanish listeners of English can be generalized to other languages with large vowel inventories such as Dutch.

Learners' initial L2 development may be equivalent to that of naïve listeners. That is, naïve listeners' cross-language categorization of the nonnative language's vowels may be predictive of initial L2 learning, as described in Escudero's (2005) Second-Language Linguistic Perception (L2LP) model and Best and Tyler's (2007) Perceptual Assimilation Model extended to L2 learners (PAM-L2). Many studies which involve cross-language identification tasks have been carried out on *learners* of the target language rather than *naïve listeners*. However, learners, especially those with substantial L2 experience, may learn to make use of acoustic–phonetic cues or dimensions in the perception of L2 vowels that they may not otherwise attend to for the perception of L1 vowels. Hence the results of a cross-language identification task performed by

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experienced *learners* may be poorly indicative of L2 perceptual problems because a degree of learning has already taken place (e.g., Iverson and Evans, 2007). That is, a learner's L2 targets may deviate further from her L1 targets as a function of L2 experience. In order to avoid such possible effects of perceptual learning, the perceived similarity between L1 and L2 vowels from a non-native identification task may be better predictive of initial L2 perceptual problems if undertaken by *naïve listeners* rather than L2 learners (e.g., Gilichinskaya and Strange, 2010; Escudero and Chládková, 2010).

Escudero and Wanrooij (2010) have shown that specific perceptual problems persist for learners of Dutch with various L1 Spanish backgrounds. The authors report that native Dutch listeners substantially outperformed both beginner and advanced Spanish learners of Dutch on a two-alternative forced-choice identification task involving five Dutch vowel contrasts. In addition, while duration is not used to contrast vowels in Spanish, Spanish learners of Dutch have been shown to exploit duration in the Dutch /aː-ɑ/ contrast, unlike Dutch native listeners who mainly use the vowels' spectral difference (Escudero *et al.*, 2009). This situation is comparable to how Spanish learners of English have often been shown to make use of duration in learning the English /iː-ɪ/ contrast (Morrison, 2009; Escudero and Boersma, 2004) even though English listeners do not appear to make use of duration for distinguishing these two vowels (Hillenbrand *et al.*, 2000). The present study complements these studies on learners of Dutch by focusing on naïve listeners from a single Spanish dialect, namely Peruvian Spanish, which will allow us to make specific predictions for a homogeneous L2 learner group.

The Dutch vowel inventory consists of 12 monophthongs and 3 diphthongs, some of which also differ in length (Adank *et al.*, 2004). The Spanish vowel inventory, on the other hand, consists of 5 monophthongs /i, e, a, o, u/ and 14 diphthongs /ie, ei, ia, ai, io, oi, iu, ui, ua, au, ue, eu, uo, ou/ (Manrique, 1979), but vowel length is not considered a contrastive feature. In this study, 12 Dutch monophthongs /i, y, ɪ, ʏ, ø, e, ɛ, a, ɑ, ɔ, o, u/ were considered, all of which were represented by natural tokens taken from a corpus reported in a recent acoustic study of Dutch vowels (Adank *et al.*, 2004). Most cross-language experiments, including very recent ones, have used stimuli produced by a single speaker (cf. Gilichinskaya and Strange, 2010) or synthetic stimuli (cf. Escudero and Chládková, 2010). A single speaker's vowels may reflect idiosyncratic speech production rather than typical productions of the language at hand, which may affect the extension of the results to a population. Additionally, most synthetic stimuli do not faithfully represent all static and dynamic properties of natural speech, which could also affect the ecological validity of the findings. We avoid these possible limitations by presenting listeners with natural vowel productions from multiple talkers, ten males and ten females, a corpus which more closely resembles real life.

Unlike previous nonnative perception studies which only include monophthongs as options from the listeners' native language, the present study includes the five Spanish monophthongs and four of the fourteen Spanish diphthongs. It will be shown that this inclusion of more options was necessary for listeners to better categorize some Dutch vowels.

2. Method

2.1 Participants

Forty monolingual speakers of Peruvian Spanish from Lima (20 males, 20 females) participated in this study. Their ages ranged from 18 to 30 yr. None reported knowledge of any other language greater than 2 on a scale from 0 to 7 (0 = no knowledge, 7 = native-like knowledge) and none reported any hearing problems. Listeners were paid for their participation.

2.2 Stimuli

The stimuli set consisted of 240 naturally produced vowel tokens, representing 20 instances of each of 12 Dutch vowels /i, y, ɪ, ʏ, ø, e, ɛ, a, ɑ, ɔ, o, u/ produced by 20

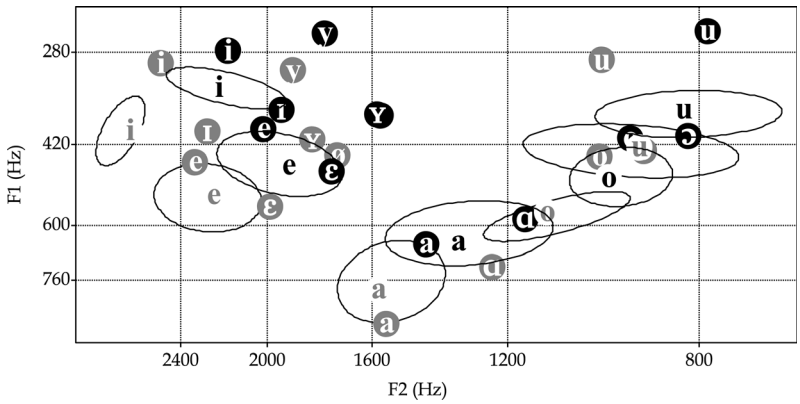

Fig. 1. Mean F1 and F2 values for 12 Northern Dutch monophthongs produced by females (white symbols in gray circles) and males (white symbols in black circles) and for five Peruvian Spanish monophthongs produced by females (gray symbols in white circles) and males (black symbols in white circles). The ellipses surrounding each Peruvian Spanish vowel represent two standard deviations of the mean.

speakers (ten males and ten females) of Standard Northern Dutch. The 240 isolated vowels were extracted from the 20 speakers' first production of /s/-vowel-/s/ words reported in Adank *et al.* (2004). We chose to present participants with isolated vowels to avoid the effect of consonantal context on perceptual assimilation patterns, which has been found in many recent studies (for a review, see Levy, 2009).

Figure 1 shows the average F1 and F2 values for the female and male Peruvian Spanish vowel productions reported in Chládková *et al.* (unpublished) and the average F1 and F2 values of the Dutch stimuli.

Although the 12 Dutch vowels are traditionally described as monophthongs, the three long mid vowels /e, ø, o/ are sometimes described as "potential diphthongs" on account of them exhibiting formant movement resembling that of closing diphthongs, especially in varieties of Northern Dutch (Collins and Mees, 2003; Adank *et al.*, 2004). The typical dynamic formant characteristics of these three Dutch vowels can clearly be seen in Fig. 8 in Adank *et al.* (2007, p. 1137).

Based on the acoustic comparison of the Peruvian Spanish (Chládková *et al.*, unpublished) and Northern Standard Dutch vowels in Fig. 1, it is expected that Dutch /i, y, ɛ, a, u/ will be classified in terms of their acoustically closest Spanish counterparts /i, i, e, a, u/. The Dutch vowels /ɪ, ɑ, ɔ/ are acoustically close to two Spanish vowel categories and are expected to be categorized as the two respective Spanish vowels /i-e/, /a-o/ and /o-u/. Although Dutch /ʏ/ and /ø/ lie in the middle of the Spanish vowel space, Dutch /ʏ/ is expected to be classified mainly in terms of the acoustically closest Spanish vowel /e/, while Dutch /ø/ is predicted to be classified as the Spanish diphthongs /eu/ or /ei/ due to its formant movement. Since the Dutch mid long vowels /e/ and /o/ also exhibit a degree of formant movement, it is expected they will be mainly categorized as the Spanish diphthongs /ei/ and /ou/, respectively.

2.3 Procedure

The experiment was carried out in a quiet room at the Pontificia Universidad Católica del Perú in Lima. Listeners performed a multiple forced-choice identification task, which was implemented using the computer program PRAAT (Boersma and Weenink, 1992–2010). They were told that they were going to hear instances of Spanish vowels recorded in running speech. The 240 Dutch stimuli were played in a randomized order over headphones at a comfortable listening level. Each trial consisted of a vowel token that listeners identified by selecting on the computer screen one of the nine Spanish vowel response options, which were written using standard Spanish orthography. The possible response options included orthographic transcriptions of the five Spanish

Table 1. Percentage categorization of Dutch vowels as Spanish vowels.

		Dutch vowel stimulus											
		i	ɪ	y	ʏ	ɛ	a	ɑ	ɔ	u	e	ø	o
Spanish vowel label	i	94	39	59	10	—	—	—	—	—	—	—	—
	e	—	49	—	53	89	—	—	—	—	26	26	—
	a	—	—	—	—	—	96	59	—	—	—	—	—
	o	—	—	—	—	—	—	33	72	—	—	—	8
	u	—	7	32	25	—	—	—	11	91	—	6	—
	ei	—	—	—	—	—	—	—	—	—	71	32	—
	eu	—	—	—	—	—	—	—	—	5	—	22	—
	ue	—	—	—	—	—	—	—	6	—	—	—	9
	ou	—	—	—	—	—	—	—	7	—	—	9	81

monophthongs /i, e, a, o, u/ and the four Spanish diphthongs /ei, eu, ue, ou/. Out of the 14 Spanish diphthongs, these four Spanish diphthongs were represented in the response options because the three Dutch mid long vowels /e, ø, o/ exhibit a large degree of formant movement with comparable onsets and glides, as mentioned in Sec. 2.2. Listeners were told to always choose a response, even if unsure. The between-trial interval was 1 s and listeners could take a short break after every 24 trials. Before the experiment began, participants were given 12 practice trials, each containing one of the 12 Dutch vowels. The purpose of the practice trials was to familiarize the listeners with the kinds of stimuli to be encountered and the task itself. The results of the practice trials were not included in the analysis. The task took listeners approximately 20 min to complete.

3. Results

Table 1 presents the percentage of times a Spanish label was selected for each of the 12 Dutch vowels, using summed responses across all 40 listeners. The table only shows Spanish vowel responses that listeners used at least 5% of the time.

In line with the acoustic comparisons, it appears that the four Dutch vowels /i, ɛ, a, u/ were overwhelmingly (i.e., >89% of the time) assimilated to the Spanish category with the closest F1/F2 values, namely Spanish /i, e, a, u/, respectively. Similarly, in line with the acoustic comparisons, Dutch /y/ mostly assimilated to Spanish /i/ and also to Spanish /u/ 32% of the time. As predicted, the Dutch vowels /ɪ/ and /ɑ/ were frequently assimilated to the two acoustically closest Spanish vowel categories, as can been seen in Fig. 2. Contrary to the predictions, Dutch /ɔ/ was mainly assimilated to just Spanish /o/ rather than to both Spanish /o/ and /u/. While Dutch /ʏ/ was mainly assimilated to Spanish /e/ as predicted, it was also assimilated to Spanish /i/ and /u/. As expected, the three Dutch long mid vowels /e, ø, o/ assimilated mainly to Spanish diphthongs, but Dutch /ø/ was categorized least consistently, being frequently assimilated to the three Spanish vowels /e, ei, eu/.

Given that there are only five Spanish monophthongs and nine steady-state Dutch monophthongs, it is not surprising there were a number of single category assimilations. That is, multiple nonnative vowels assimilated to a single native vowel category [e.g., as per Best's (1995) Perceptual Assimilation Model]. The L2LP model states that the *initial stage* of L2 learning is predictable based on these observed assimilation patterns. Specifically, the more a L2 contrast assimilates to separate L1 categories (i.e., the stronger the two-category assimilation), the less demanding learning the new contrast will be. Conversely, the more strongly a L2 contrast assimilates to a single L1 category (i.e., the stronger the single category assimilation), the more difficult discriminating the contrast is and hence the more difficult L2 learning will be.

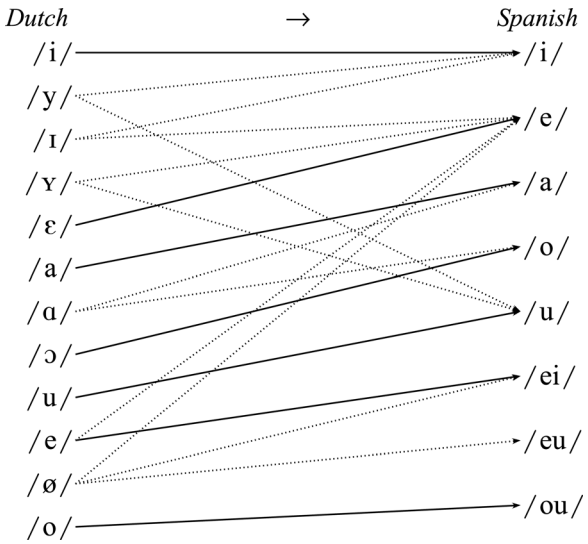

Fig. 2. Assimilation patterns. 70% or more = solid arrows, 25%–60% = dashed arrows.

For instance, the perception of Dutch vowel contrasts involving two of the five Dutch vowels /i, ɛ, a, ɔ, u/ is expected to be relatively easy for L2 learners since these vowels were each primarily mapped (>70% of the time) onto separate Spanish vowel categories, namely /i, e, a, o, u/, respectively. Similarly, the Dutch mid long vowels in the Dutch /e-o/ contrast were frequently assimilated to separate Spanish diphthong categories, namely /ei/ and /ou/.

On the other hand, the perception of those L2 vowel contrasts which are involved in single category assimilations is expected to be difficult, especially if the majority of tokens in a nonnative contrast are assimilated to the same L1 vowel. For example, although Dutch /ɑ/ partially assimilated to Spanish /o/, the vowels in the Dutch /a-ɑ/ contrast were the only Dutch vowels to be perceived in terms of Spanish /a/. Spanish learners are therefore expected to find this contrast very difficult.

The Dutch three-way contrast /ʏ-ɛ-ɪ/ is also expected to be difficult since these vowels are involved in a single category assimilation in which the majority of tokens were categorized as Spanish /e/. Although Dutch /ɛ/ was most frequently assimilated to Spanish /e/, Dutch /ɪ/ and /ʏ/ were given the Spanish label /e/ approximately 50% of the time and were also partially assimilated to two other separate Spanish vowel categories, namely /i/ and /u/, respectively. Learners are therefore expected to hear the three-way contrast only some of the time. Additionally, Dutch /e/ and /ø/ were partially assimilated to Spanish /e/ but as listeners categorized the majority of tokens of these two Dutch vowels in terms of Spanish diphthongs, it is expected that learners will be able to distinguish them from the Dutch monophthongs /ʏ, ɛ, ɪ/ reasonably well, but learners may encounter some difficulty perceiving the Dutch /e-ø/ contrast since both of these Dutch partially assimilated to Spanish /ei/.

The Dutch three-way contrast /i-ɪ-y/ is predicted to be relatively difficult for learners since these vowels were all frequently given the Spanish label /i/. However, Dutch /ɪ/ and /y/ were also partially assimilated to two further Spanish vowels, namely /e/ and /u/, respectively, and as a result Spanish learners are expected to hear different vowels some of the time.

Dutch /u/ was primarily assimilated to Spanish /u/. Despite Dutch /ʏ/ and /y/ vowels exhibiting considerably higher F2 values, they were also categorized as Spanish /u/, 25% and 32% of the time, respectively. Nevertheless, the majority of Dutch /ʏ/ and /y/ tokens were perceived as other Spanish vowels, namely to /e/ and /i/, respectively.

As a result of this assimilation pattern, discrimination of the Dutch vowels in the three-way contrast /u-ʏ-y/ is expected to be moderately difficult for learners.

4. Discussion

The aim of the present experiment was to assess naïve Spanish listeners' categorization of 12 Dutch vowels in order to make predictions about L2 development. It appears that the listeners' categorization of Dutch vowels was generally predictable based on the acoustic similarity between Spanish and Dutch vowels and it is not surprising that there were a number of single category assimilations since there are more Dutch than Spanish monophthongs. In addition, the Spanish listeners frequently made use of the Spanish diphthong response options in their categorization of the three Dutch mid long vowels /e, ø, o/. Within the framework of Escudero's (2005) L2LP model, the specific assimilation patterns displayed in the results are suggestive of the *initial* stage of Spanish learners of Dutch and with these predictions can be made regarding Spanish learners' *further* L2 development.

According to the L2LP, the degree of perceived similarity between two contrasting L2 vowels and a L1 vowel category determines whether L2 learners are presented with the learning task of either shifting a category boundary, splitting an existing L1 category, or creating a new category altogether. As observed, most tokens of Dutch /i, ɛ, a, ɔ, u, e, o/ were assimilated primarily to Spanish /i, e, a, o, ei, ou/, respectively, while tokens of Dutch /ɪ, y, ʏ, ɑ, ø/ were categorized in terms of two or more Spanish vowel categories, namely /i-e, i-u, e-u, e-ei-eu/, respectively. Thus in order to successfully acquire all Dutch vowel contrasts, it is likely that learners will have to create new categories or split existing ones to accurately perceive the latter five Dutch vowels /ɪ, y, ʏ, ɑ, ø/.

Since Dutch /ɪ/ is perceived in terms of both Spanish /i/ and /e/, a Spanish learner of Dutch will need to shift her boundaries for these two Spanish categories on the F1 dimension so that most tokens of /ɪ/ are perceived as /e/. However, this will require a further split of Spanish /e/ in order to accommodate Dutch /ɛ/. For Dutch /y/ and /ʏ/, two categories along the F2 dimension need to be created between Spanish /i/ and /u/, one with the same F1 value and another with an F1 value similar to that of Spanish /e/. For the Dutch vowel /ɑ/, a learner may have to split her /a/ category or shift her /a-o/ boundary to accommodate Dutch /ɑ/. Finally, for the Dutch vowel /ø/ it may be easier to create a new category because it does not sound like any single Spanish vowel. In such a case of multiple category assimilation (cf. Escudero and Boersma, 2002), a Spanish learner of Dutch may try to form a new category based on Spanish /eu/, given that this L1 diphthong will lead to the least confusions with other Dutch vowels such as Dutch /e/.

In line with previous studies on the perception of English by individuals with smaller L1 vowel inventories, the present study has shown that single category assimilations are common, but that some Dutch vowels are assimilated primarily to one Spanish vowel and others to two. According to models such as the L2LP and PAM-L2, these assimilation patterns of nonnative vowels to native vowels may be predictive of L2 learning. On the basis of the observed assimilation patterns in the present study, predictions have been made on Peruvian Spanish learners' initial and further stages of L2 development. To test these predictions further research on Peruvian Spanish learners of Dutch is required.

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