Perceptual assimilation of British English vowels to Spanish monophthongs and diphthongs

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Abstract: This study examined the perceived similarity between Standard British English vowels and Spanish vowels, including Spanish diphthongs, not usually considered in studies on cross-language categorization. Twenty-nine Spanish speakers performed two perceptual assimilation tasks that differed in the number of response alternatives provided, that is, including or excluding diphthongs. The participants also performed an L1 vowel identification task. The results showed that Spanish listeners consistently perceived English diphthongs as closer to Spanish diphthongs than to Spanish monophthongs, with comparatively high assimilation scores. These results emphasize the need to include diphthongs in cross-language comparisons and second-language acquisition studies involving languages like Spanish.

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1. Introduction

Most models of second language (L2) speech such as the Perceptual Assimilation Model (PAM-L2; Best and Tyler, 2007), the L2 Linguistic Perception model (Escudero, 2009), and the Speech Learning Model (SLM; Flege, 1995), among others, relate the likelihood of accurate L2 category formation to the degree of similarity between the existing L1 categories and the target L2 sounds. Therefore, determining the degree of similarity between the L1 and L2 sounds is crucial in order to make predictions about the learnability of target-language categories. Ideally, an accurate description of cross-language similarity should include all the relevant sounds from the languages examined.

Some previous studies (e.g., Flege *et al.*, 1994; Imai *et al.*, 2002; Iverson and Evans, 2007) have investigated the acquisition of English vowels by native speakers of Spanish and have addressed the issue of cross-linguistic similarity. These comparisons have typically involved the whole set or a subset of the English vowel system and the five Spanish vowel monophthongs. For instance, in a study investigating the relationship between L1 inventory size and L2 perception, Iverson and Evans (2007) assessed the perceived similarity between 14 British English vowels and the five Spanish monophthongs /i e a o u/. They found that English /aɪ/ and /aʊ/ obtained very low identification scores as the acoustically closest Spanish monophthong /a/, and thus had a poor match in the L1. Since Spanish diphthongs such as /ai̯/ and /au̯/ were not included as possible responses in the mapping task, it is not known whether Spanish speakers would consider their L1 diphthongs as possible matches to the English categories. Imai *et al.* (2002) investigated the acoustic and perceived similarity between American English /i eᴵ ɑ oʊ u ɪ ɛ æ ʌ ʊ ɚ/ and Spanish /i e a o u/. They reported that vowels like /eᴵ oʊ/ have greater formant movement and duration than the Spanish monophthongs /e o/, but Spanish diphthongs such as /ei̯ ou̯/ were not considered. Similarly, Flege *et al.* (1994) obtained ratings of perceived dissimilarity between American English /i ɪ eᴵ ɛ æ ʌ ɑ/ and Spanish /i e a/, excluding Spanish /ei̯/. The results of these previous studies provided informative depictions of the degree of similarity between the vowel categories examined, but they may be incomplete because Spanish diphthongs were not taken into account.

Spanish diphthongs are sequences of one of the five vowel monophthongs (/a e i o u/) and a high glide [/i̯ u̯/, using Hualde's (2005) notation]. Examples are /ei̯/ in *ley*, "law," /ai̯/ in *hay*, "there is," or /eu̯/ in *euro*, "euro currency." Possibly the reason why such sequences have not been considered in previous cross-language comparisons is related to their biphonemic nature. Unlike the nuclear monophonemic diphthongized vowels of English, such as /eɪ/ in *ray*, Spanish diphthongs are described as tautosyllabic biphonemic sequences consisting of a vowel in the nucleus and a glide in the syllable

margin, such as /ei̯/ in *rey*, "king" (e.g., Quilis, 1993; Hualde, 2005).[1] In addition, in contrast with the lack of formant movement in Spanish monophthongs (e.g., /e/ in *reno*, "reindeer"), vowel-glide sequences (e.g., /ei̯/ in *reino*, "kingdom") are characterized by greater formant trajectories than English diphthongs, like /eɪ/ in *rain* (e.g., Borzone de Manrique, 1979; Hillenbrand *et al.*, 1995).

Some previous studies provide evidence that biphonemic sequences like Spanish diphthongs play a role in cross-linguistic perception. Escudero and Williams (2011) found that Peruvian Spanish speakers assimilated the Dutch vowels /e/, /o/, and /ø/, which are more diphthongized than the rest of the Dutch vowels, to Spanish diphthongs (namely /e/ to /ei̯/, /o/ to /ou̯/ and /ø/ to /ei̯/, /e/ and /eu̯/). Further, previous studies have found that Catalan listeners consistently assimilate English /eɪ, oʊ, aɪ, aʊ/ to the Catalan biphonemic sequences /ei̯, ou̯, ai̯, au̯/, respectively (see Cebrian, 2011).

The current study aims to investigate the perceived similarity between Spanish and Standard Southern British English (SSBE) monophthongs and diphthongs and to assess the role of Spanish diphthongs in cross-linguistic perception. To this effect, a group of Spanish speakers completed two perceptual assimilation tasks (PATs). In one task, the response alternatives were limited to the five Spanish monophthongs (/i e a o u/). In the other task, participants were also provided with six Spanish falling diphthongs /ai̯, ei̯, oi̯, au̯, eu̯, ou̯/ as possible response alternatives in addition to the monophthongs. If Spanish listeners categorize all English vowels in terms of Spanish monophthongs, the modal responses across the two tasks should be comparable. By contrast, if Spanish diphthongs play a role in the categorization of some English vowels, there should be a difference between the two tasks in the choice of response as well as the goodness ratings assigned. Participants also performed a Spanish vowel identification task, whose purpose was to obtain baseline L1 identification, and to assess whether participants used the Spanish response alternatives correctly and consistently.

2. Method

2.1 Participants

Twenty-nine undergraduate students majoring in Spanish or Psychology at Universitat Autònoma de Barcelona participated in the experiment (18 females, 11 males, mean age: 21.2, range: 19–32). The participants were all native speakers of Spanish although some spoke Catalan as well. Participants completed an online questionnaire based on the Bilingual Language Profile (BLP; Birdsong *et al.*, 2012), which establishes the language dominance of the respondents by means of a series of questions about language background and use. According to the BLP, six participants were found to be slightly more dominant in Catalan than Spanish. An analysis of these participants' responses revealed that they did not differ from the remaining Spanish speakers' performance, neither in the identification of Spanish vowels nor in the PATs. Further, they were all found to speak Spanish natively in a conversation with the experimenters. Thus, the performance of all 29 participants was analyzed. Regarding familiarity with English, most participants had only passive knowledge. The majority had taken English in high school, had been exposed to the target language only in the home country, often from non-native instructors, reported a beginner to intermediate level of English, and indicated that they rarely used English in their everyday life.

2.2 Stimuli

The stimuli for the PAT were 14 SSBE vowels /iː, ɪ, ɛ, eɪ, aɪ, æ, ɑː, aʊ, ɒ, ɔː, əʊ, ɜː, ʌ, uː/.[2] The Spanish L1 identification task included all five Spanish monophthongs plus six Spanish falling diphthongs /i, e, a, o, u, ai̯, ei̯, oi̯, au̯, eu̯, ou̯/. Although /ou̯/ is rare in Spanish words, in Spain it is found in place names (*Ourense, Salou*), common last names (*Sousa, Tous*), acronyms (*LOU*), and the Spanish pronunciation of borrowings (*show*). Stimuli were naturally produced by four male speakers of SSBE (mean age: 35, range: 29–44) and three male speakers of European Spanish (mean age: 47, range: 36–59), recorded in London and Barcelona, respectively. One of the SSBE speakers knew some Spanish and the three Spanish speakers knew other languages (Catalan and/or English), but for all speakers English or Spanish was their dominant and native language, according to the language background questionnaire. Vowels were elicited in /b/-V-/t/ words in English and in /b/-V-/ta/ words in Spanish and produced in comparable carrier phrases. The recordings were digitized at a 44 kHz-sampling rate and the stimuli from both languages were normalized for intensity (70 dB). The best tokens per talker were selected, based on auditory judgments and inspection of the spectrogram. Stimuli were edited to eliminate variation in the prevoicing of the /b/ and the release of

the /t/. Thus, final stimuli included from the release of the /b/ to the point of complete constriction of the /t/, maintaining the vowel portion intact.

2.3 Tasks

In the PATs listeners heard an English vowel stimulus and had to identify it as one of several possible L1 categories by clicking on one of the response alternatives presented on a computer screen. Next listeners provided a goodness of fit rating (henceforth GR) on a 7-point scale, where 1 meant a poor or bad rendering of the selected sound and 7 meant a good, native-like example. The two tasks differed in the number of response alternatives. In the 5-alternative monophthongs-only condition (henceforth 5A), the responses were the five Spanish monophthongs represented by their common spelling accompanied by an example word, namely *A (la)*, *E (se)*, *I (si)*, *O (no)*, *and U (su)* (the feminine article, the reflexive pronoun, *yes*, *no*, and *his/her*, respectively). In the 11-alternative monophthongs and diphthongs condition (11A), six more response alternatives were added, namely *AY (hay)*, *EY (ley)*, *AU (auto)*, *EU (euro)*, *OU (Salou)*, *and OY (hoy)* (*there is*, *law*, *automobile*, *euro*, a well-known resort town, and *today*, respectively). The total number of trials in the PATs was 112 (14 vowels × 4 speakers × 2 tokens). Participants were not told specifically that they would hear English stimuli but they were informed that stimuli might vary in how native-like they sounded and were encouraged to use the whole range of numbers on the GR scale. Each task was preceded by a short practice session consisting of eight trials to familiarize participants with the task procedure and the response options. The Spanish identification task contained the same response alternatives as the 11A PAT and a total of 66 trials (11 Spanish monophthongs and diphthongs × 3 talkers × 2 tokens). Stimuli were randomized in all tasks. Fifteen participants performed the 5A PAT first, followed by the 11A PAT. The remaining 14 participants performed the 11A PAT first, then the 5A PAT. All participants completed the Spanish identification task last. All three tasks were administered using Praat (Boersma and Weenink, 2018).

3. Results

3.1 L1 vowel identification task

The percent correct identification of the five Spanish monophthongs and the six diphthongs and the corresponding mean GRs were calculated. Correct identification reached 97%–99% in all cases except for the diphthong /ei̯/ and the vowel /o/ (92%–93%), and the vowel /e/, which obtained lower identification rates (78%). In this latter case, most errors involved misidentifications as /i/ (21%), and may be related to a closer articulation of /e/ in pre-coronal context (Morrison, 2004; Navarro Tomás, 1965). The GRs obtained for the correct identifications ranged from 4.7 to 5.9.

3.2 PATs

The percentage of times participants identified each target vowel as one of the Spanish responses (i.e., assimilation scores) and the corresponding mean GR were calculated for each condition. To test if task order influenced the results a generalized logistic mixed model was used, with order (5A+11A vs 11A+5A) and condition (5A vs 11A) as fixed factors, and participant and token as random factors. The dependent measure was the identification percentage for each target vowel as the modal response in the 5A condition, as the 5A responses were found in both tasks. The results showed a significant effect of condition [$F(1,6.492) = 8.899$, $p = 0.003$], but neither the effect of order nor the order by condition interaction reached significance [$F(1,6.492) = 0.373$, $p = 0.542$, $F(1,6.492) = 0.001$, $p = 0.98$]. Hence, the results for the two orders were collapsed. Tables 1 and 2 present the confusion matrices showing the percentage assimilation of each SSBE vowel to each Spanish category and the corresponding GR in the 5A and 11A conditions, respectively. Only responses equal or greater than 5% are shown. Modal responses are highlighted in bold.

The pattern of English to Spanish assimilations was basically identical in both conditions for the SSBE monophthongs, with very similar assimilation scores and GR. However, the results for the English diphthongs differed greatly depending on the task: in the 5A condition, SSBE /eɪ, aɪ, aʊ, əʊ/ were identified with the Spanish monophthongs /e, a, a, o/, respectively, between 70% and 83% of the time, with GR ranging from 3.4 to 3.9. By contrast, in the 11A condition, SSBE /eɪ, aɪ, aʊ, əʊ/ were identified with Spanish monophthongs less than 3% of the time, and were consistently assimilated to Spanish /ei̯, ai̯, au̯, ou̯/, respectively, between 84% and 97% of the time. Further, the GR obtained as Spanish diphthongs ranged from 4.8 to 5.6, mostly within the range of GR obtained in L1 vowel identification task (4.7–5.9). The difference in

Table 1. Percentage assimilation of SSBE vowels to Spanish vowels (Sp. resp.) in the monophthong-only response condition (PAT 5A). Goodness ratings are given in parentheses.

	English vowel stimuli													
Sp. resp.	iː	ɪ	ɛ	æ	ɑː	ɜː	ʌ	ɒ	ɔː	uː	eɪ	aɪ	aʊ	əʊ
i	**99** **(5.8)**	41 (4.8)									13 (2.4)	17 (3.0)		
e		**59** **(5.2)**	**98** **(5.6)**			**62** **(3.0)**					**74** **(3.9)**			
a				**99** **(5.5)**	**75** **(4.5)**	25 (3.2)	**97** **(5.4)**	24 (4.1)			13 (2.7)	**70** **(3.8)**	**83** **(3.7)**	
o					25 (4.4)	12 (3.7)		**75** **(5.2)**	**85** **(4.3)**			10 (2.8)		**81** **(3.4)**
u									13 (4.4)	**96** **(4.9)**			12 (3.5)	15 (3.2)

assimilation percentages to the modal responses in each condition obtained by each English diphthong (i.e., /eɪ, aɪ, aʊ, əʊ/ as /e, a, a, o/ in the 5A PAT vs /eɪ, aɪ, aʊ, əʊ/ as /e̯i̯, a̯i̯, a̯u̯, o̯u̯/ in the 11A PAT) was examined in a series of generalized logistic mixed models, one per target diphthong, with condition as fixed factor and participant and token as random factors. The results, given in Table 3, show that the assimilation scores and GR were always significantly higher in the 11A condition underscoring that all four SSBE sounds (/eɪ, aɪ, aʊ, əʊ/) were unequivocally perceived to be closer to Spanish diphthongs than to Spanish monophthongs.

Given the results reported in Table 3 and the minimal differences across conditions for the monophthongs, the general pattern of assimilation of SSBE to Spanish vowels will be explored on the basis of the results of the 11A PAT (Table 2). A few SSBE vowels were perceived as very close to their Spanish counterparts, with assimilation scores and GRs that fell within the identification scores and GR obtained in the L1 vowel identification task. This is the case of the assimilation of English /iː, ɛ, æ, ʌ, aʊ/ to Spanish /i, e, a, a, au/, respectively, with assimilation rates above 94% and GR greater than 5. English /uː, eɪ, aɪ, əʊ/ were also consistently perceived as Spanish /u, ei,

Table 2. Percentage assimilation of SSBE vowels to Spanish vowels (Sp. resp.) in the monophthong and diphthong response condition (PAT 11A). Goodness ratings are given in parentheses.

	English vowel stimuli													
Sp. resp.	iː	ɪ	ɛ	æ	ɑː	ɜː	ʌ	ɒ	ɔː	uː	eɪ	aɪ	aʊ	əʊ
i	**95** **(5.9)**	33 (5.0)												
e		**66** **(5.3)**	**97** **(5.3)**			**64** **(3.0)**								
a				**99** **(5.4)**	**72** **(4.0)**	14 (3.4)	**96** **(5.3)**	19 (3.6)						
o					17 (4.5)	13 (3.9)		**76** **(4.7)**	**75** **(4.1)**					
u									9 (3.8)	**91** **(4.6)**				
e̯i̯											**88** **(5.6)**			
e̯u̯														
a̯i̯											8 (5.4)	**84** **(5.1)**		
a̯u̯					6 (4.1)								**97** **(5.3)**	5 (4.6)
o̯i̯												13 (5.2)		
o̯u̯									12 (3.7)					**89** **(4.8)**

Table 3. Outcome of statistical analyses examining the effect of condition per target diphthong.

Target diphth.	Cond.	Modal resp.	Assim. score	Statistical result	GR	Statistical result
eɪ	5A	e	74%		3.9	
	11A	e̯i̯	88%	$F(1,414) = 13.9, p < 0.001$	5.6	$F(1,414) = 229.7, p < 0.001$
aɪ	5A	a	70%		3.8	
	11A	a̯i̯	84%	$F(1,414) = 13.79, p < 0.001$	5.1	$F(1,414) = 145.9, p < 0.001$
aʊ	5A	a	83%		3.7	
	11A	a̯u̯	97%	$F(1,414) = 17.54, p < 0.001$	5.3	$F(1,414) = 168.1, p < 0.001$
əʊ	5A	o	81%		3.4	
	11A	o̯u̯	89%	$F(1,414) = 8.11, p < 0.01$	4.8	$F(1,414) = 99.4, p < 0.001$

ai, ou/, respectively (84%–91%, GR: 4.6–5.6). Other vowels were predominantly perceived as a single Spanish vowel but with lower rates and GR, e.g., SSBE /ɒ, ɔː, ɑː, ɪ/ as Spanish /o, o, a, e/ (66%–76%, GR: 4.0–5.3). Finally, /ɜː/ obtained the lowest assimilation rates and GR as Spanish /e/ (64%, 3), constituting the most dissimilar of the SSBE vowels for Spanish speakers. The consequences of these assimilation patterns are briefly discussed in Sec. 4.

4. Discussion

The goal of this study was twofold: to examine the perceived similarity between SSBE and Spanish monophthongs and diphthongs, and to evaluate the role of biphonemic sequences like Spanish diphthongs in cross-linguistic perception. Regarding the latter, the results of the PATs provide strong evidence that Spanish diphthongs play a role in the categorization of diphthongized sequences like SSBE /eɪ, aɪ, aʊ, əʊ/. These sequences were predominantly identified as the Spanish diphthongs /e̯i̯, a̯i̯, a̯u̯, o̯u̯/ when the L1 diphthongs were possible response alternatives (11A PAT). When only monophthongs were included in the set of response options, English diphthongs obtained significantly lower assimilation scores and GR as Spanish categories. These results are in line with previous findings showing that Spanish speakers assimilate Dutch diphthongized vowels to Spanish diphthongs (Escudero and Williams, 2011) and that Catalan, Japanese, and Korean speakers consistently map English diphthongs perceptually onto L1 diphthongs (Cebrian, 2006, 2011; Frieda and Nozawa, 2007). These findings thus call into question the exclusion of these sequences in some earlier studies (Imai *et al.*, 2002; Flege *et al.*, 1994). For example, as discussed above, Iverson and Evans (2007) did not include Spanish diphthongs as possible responses in their cross-language mapping task. Their results showed that the SSBE diphthongs /aʊ, aɪ, eɪ, əʊ/ assimilated to Spanish /a, a, e, o/, respectively, but obtained the lowest assimilation scores among all English vowels. In addition, the outcome of a vowel-space mapping task showed that the Spanish learners of English preferred /aʊ/, /aɪ/, and /eɪ/ tokens that were closer to native English vowels than to the supposedly closest Spanish vowels /a/ and /e/. This was interpreted as evidence of L2 learning since the Spanish speakers were relying on formant movement in a native-like (i.e., English-like) fashion. However, the current results suggest that the closest Spanish sounds to English /aʊ/, /aɪ/, and /eɪ/ are in fact the diphthongs /a̯u̯/, /a̯i̯/, and /e̯i̯/. Thus, while learning may still have occurred, the Spanish speakers in Iverson and Evans (2007) may have been modelling the English diphthongs after their own L1 diphthong categories.

Regarding the general patterns of perceived similarity between SSBE and Spanish vowels, the results show that a number of target vowels received very high assimilation scores and GR, namely SSBE /iː, ɛ, æ, ʌ, aʊ/ to Spanish /i, e, a, a, a̯u̯/, followed by SSBE /uː, eɪ, aɪ, əʊ/ to Spanish /u, e̯i̯, a̯i̯, o̯u̯/, respectively. As it will be difficult for learners to detect differences between the L1 and target language vowels, these vowels are likely to be perceived and produced in terms of the L1 categories, at least initially (Flege, 1995). English /æ/ and /ʌ/ exemplify a single-category assimilation in PAM-L2's terms (Best and Tyler, 2007), as the two SSBE vowels are assimilated to Spanish /a/. This scenario predicts great difficulty distinguishing the two members of the English contrast. Another case of single-category assimilation is illustrated by SSBE /ɒ/-/ɔː/ and Spanish /o/. English /ɑː/ was also predominantly assimilated to Spanish /a/ but with notably lower scores than /æ/ or /ʌ/. Thus the SSBE contrasts /ɑː/-/æ/ and /ɑː/-/ʌ/ constitute examples of PAM-L2's category goodness assimilations, expected to be better discriminated than the single-category assimilation /æ/-/ʌ/ (Best and

Tyler, 2007). SSBE /ɛ/ and /ɪ/ also assimilate to the same Spanish category, /e/, but to very different degrees (97% vs 64%, respectively). Interestingly, English /ɪ/ tends to be mispronounced as Spanish /i/ more than as /e/, which may result from the influence of orthography or the unfortunate habit of teaching the /iː/-/ɪ/ contrast as a long /i/-short /i/ opposition to L2 English learners (e.g., Cebrian, 2006). Finally, vowel /ɜː/ constitutes the most novel of the English vowels for Spanish speakers, which according to the Flege's (1995) SLM, may eventually be categorized more authentically, given sufficient input and experience. Testing the predictions of these classifications lies beyond the scope of this paper and is left for future research.

The patterns of cross-linguistic assimilation described above agree with the general trend reported for SSBE monophthongs in previous studies. Iverson and Evans (2007) obtained the same modal responses as the present study for the SSBE monophthongs /iː, ɛ, æ, uː, ɒ, ɔː, ɑː/. However, English /ʌ/ and /ɜː/ were perceived as Spanish /o/ (but as Spanish /a/ and /e/, respectively, in the current study), and /ɪ/ was heard mostly as Spanish /i/ (as opposed to Spanish /e/). These discrepancies may be explained by methodological differences. Iverson and Evans' PAT was considerably shorter (28 trials with stimuli from a single speaker including two trials per target vowel, as opposed to the 112 trials from four different speakers amounting to eight trials per target vowel in the present study). Further, the 25 Spanish-speaking participants in that study were L2 English speakers living in the United Kingdom, and only six of them were from Spain. Escudero and Chládková (2010) also tested a large set of SSBE monophthongs, namely /iː, ɪ, ɛ, æ, ʌ, ɑː, ɔː, uː, ʊ/ (but not /ɜː/ and /ɒ/). In this case, discrepancies with the current results involve English /ɪ/, whose assimilation scores were split among Spanish /u/, /e/, and /i/, and English /ɑː/, with a lower assimilation score to Spanish /a/ (56% as /a/ and 43% as /o/). These cross-study differences may stem from the fact that Escudero and Chládková used isolated synthetic vowel stimuli, with static *F*1 and *F*2 and normalized duration. Further, the different L1 variety (Peruvian vs European Spanish) may have also played a role (e.g., Chládková *et al.*, 2011). Escudero and Chládková in fact tested both American English and British English vowels and found different assimilation patterns for some target vowels. Thus, further examination of the perceived similarity between English and Spanish vowels may require examining the roles of the target language variety, the L1 variety, and stimulus type, as well as other issues not addressed in this paper such as the effect of the phonetic and prosodic contexts. In any event, the results of the current study strongly suggest that sequences like Spanish diphthongs be included in future cross-language perception studies and general L2 speech research.

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References and links

[1]Note that the plural of *rey* is formed by adding /es/ (*reyes*), as is the norm for Spanish nouns ended in VC, such as *red-redes*, "net-nets," as opposed to just /s/ with words ending in a nuclear vowel (café-cafés).

[2]The English vowels /ʊ/ and /ɔɪ/ were not included as they were the only vowels to create non-words in the context in which they were elicited, i.e., /b/-V-/t/ (Iverson and Evans, 2007).

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