2017. *Proc Ling Soc Amer* 2, 11:1-9. https://doi.org/10.3765/plsa.v2i0.4051.

# Perception of Welsh vowel contrasts by Welsh-Spanish bilinguals in Argentina

Elise Bell*

**Abstract**. This study investigates the perception of Welsh vowel contrasts by Welsh-Spanish bilinguals. A two-alternative forced choice perception task elicited subjects' reliance on vowel tenseness and duration in the identification of ambiguous Welsh vowels. Results demonstrate no effect of order of acquisition on speakers' reliance on duration (over vowel quality) as a cue to vowel identity in Welsh. This supports past work demonstrating that speakers of a language which lacks a given contrast perceptually rely on the most salient phonetic dimension of that contrast in an L2. Results were also atypical: language dominance outweighed a predicted age of acquisition effect on speakers adaptation to L2 phonetic cues.

**Keywords**. bilingualism; second language acquisition; speech perception; Welsh; Spanish

**1. Introduction**. This paper presents the results of a pilot study investigating the perception of Welsh vowel length contrasts by Welsh-Spanish bilinguals in Argentina. This study was conducted in preparation for ongoing dissertation research which uses this population to test the predictions of Escudero's Second Language Linguistic Perception model (L2LP, Escudero 2005, Escudero 2009), and compares its predictive power for this linguistic situation to that of other theoretical models of second language acquisition (PAM-L2, Best & Tyler 2007; SLM, Flege 1995).

Unlike other current models of second language perception, the L2LP explicitly deals with learners at all stages of second language (L2) acquisition, making it suitable for the investigation of a minority population with a great deal of internal variation in L2 learning background, daily language use, and language dominance. The L2LP also provides explicit hypotheses regarding the correlation of perception and production ability in the L2. The theory predicts that likely areas of difficulty in L2 acquisition are predictable based on the acoustic comparison of the varieties of the first language (L1) and target language in question. Escudero & Chládková (2010) show that L1 Spanish speakers classify vowels of Southern British English differently than vowels of American English when asked to identify isolated vowels as any of the five vowels of Spanish. Comparisons of the native language vowel system to those of the two target dialects successfully predicted these patterns of assimilation.

During the L2 acquisition process, the L2LP proposes, a copy of the L1 perceptual system is created for use in perceiving the L2. The copied perceptual system is then modified during the process of L2 learning, leaving the native perceptual system intact. Compare for example the prediction of Flege's Speech Learning Model (SLM) that the L1 and L2 share a perceptual space, therefore impeding the acquisition of native-like L2 perception if and when such native-like perception would interfere with the contrastive categories present in the L1. The different predictions made by the L2LP and SLM in this case are directly testable through experimental

* Thank you to the Welsh community of Gaiman, Argentina for welcoming me during my fieldwork and for their invaluable help with this research. Thanks also to the University of Arizona's Center for Latin American Studies and the Tinker Foundation, who provided the funding that made this research possible. Author: Elise Bell, University of Arizona (elisebell@email.arizona.edu).

investigation of L2 perception ability by bilinguals at different stages of acquisition. If bilinguals with greater L2 experience are found to differ in both their L2 and L1 perceptual abilities compared to bilinguals or L2 learners with less extensive experience, this would provide evidence for the SLM's proposal that perceptual knowledge for the L1 and L2 exists in a shared space. If, however, advanced bilinguals' L2 perception ability outpaces that of early bilinguals, but their L1 perception is found to exhibit no differences, the claims of the L2LP that second language perception exists separately from native language perception would be supported.

The vowel systems of Welsh and Spanish contrast in such as way as to make this bilingual population ideal for an investigation of the L2LP. Differences in both number and type of phonemic contrasts, and in the acoustic realization of those contrasts, implies that acquisition of Welsh from an L1 Spanish background will involve significant alterations to systems governing vowel perception and production.

The vowel system of modern Welsh has 13 contrasting vowel phonemes, which are traditionally described as six duration based pairs (/ɨː-ɨ, iː-i, eː-e, aː-a, oː-o, uː-u/) and /ə/ (Awbery 1984, Hannahs 2013). Phonetically, these vowel pair contrasts are consistently produced with differences in vowel quality (a tense-lax distinction) as well as in duration (Mayr & Davies 2011). Tense vowels [i e ɑ o u] are more peripheral in the vowel space and correspond to underlying long vowels, while lax vowels [ɪ ɛ a ɔ ʊ] are less peripheral and correspond to underlying short vowels. Thus, one underlying phonological contrast (between each vowel pair) is associated with two surface acoustic continua: duration and vowel quality (Mayr & Davies 2011).[1]

Spanish, in contrast, has a total of 5 vowel phonemes (/a e i o u/), which are phonetically peripheral, spread to the edges of the vowel space. Spanish lacks a phonemic contrast in vowel tenseness, and lacks both phonemic and allophonic contrasts in vowel duration (Harris 1969).

Learning the vowel system of Welsh to a native-like degree of accuracy is predicted to be difficult for L1 Spanish speakers, because for each individual vowel of Spanish, at least two Welsh vowels share the same acoustic space (see Figure 1).

Alteration of the perceptual system to accommodate additional categories where only a single category is present in the native system is predicted to be challenging. For example, even early learners of Catalan whose native language was Spanish demonstrated difficulty distinguishing two vowels of Catalan /e/ and /ɛ/, which occupy the same acoustic space as a single vowel of Spanish /e/ (Sebastián-Gallés & Soto-Faraco). A similar prediction can be made for native Spanish speakers learning Welsh: the acoustic overlap of the two languages' vowel systems will likely impede complete acquisition of the larger Welsh vowel system. The acoustic characteristics of Welsh vowel length contrasts provide three possible pathways for acquisition by native Spanish speakers. First, learners could rely equally on both vowel duration and vowel quality to distinguish long and short vowels in minimal pairs such as *llên* [ɬeːn] 'literature' and *llen* [ɬɛn] 'curtain', or *tôn* [toːn] 'tune' and *ton* [tɔn] 'wave'. Secondly, learners could rely extensively on one acoustic cue to vowel identity alone, either vowel duration or vowel quality. Based on previous research conducted with Spanish learners of English (Bohn 1995, Flege et al. 1997), the durational acoustic correlate of vowel identity in Welsh was predicted to be more accessible to native Spanish speakers than is the co-variation in vowel quality.

[1] Vowel quality itself consists of two separate continua of height (F1) and backness (F2).

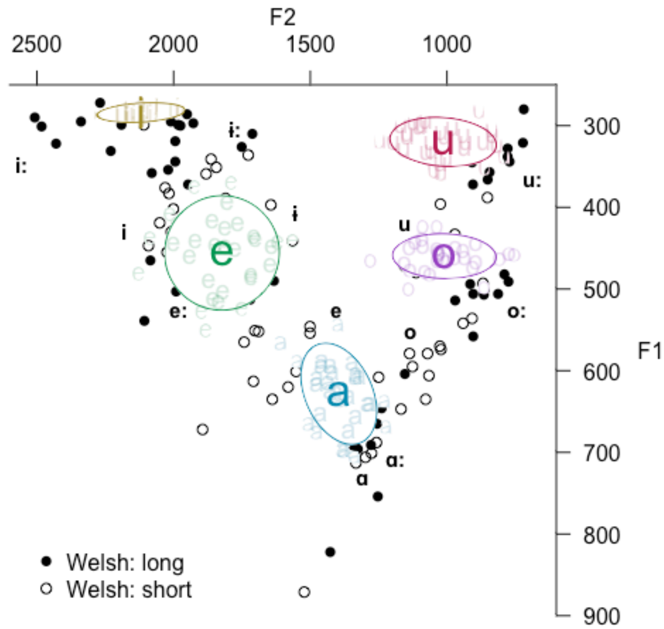


Figure 1: Spanish (colored ellipses; Bradlow 1995) and Welsh (Mayr & Davies 2011) vowels in acoustic space.

The ability of Welsh-Spanish bilinguals to rely on vowel quality as well as vowel duration as a cue to Welsh vowel identity is also predicted to vary depending on the age at which speakers acquired Welsh, and the degree to which they are Welsh-language dominant. To this end, language background data was collected for all subjects using the Bilingual Language Profile (Birdsong, Gertken, and Amengual 2012), the results of which are discussed in more detail in section 2.1 below. The following section describes the experimental methods used to test participants' reliance on vowel duration and vowel quality as cues to the identity of Welsh vowels. Results are presented in Section 3, followed by a discussion in Section 4.

**2. Methods.** A two-alternative forced choice task tested participant's reliance on vowel duration and vowel quality as cues to vowel identity to investigate the phonetic correlates of Welsh vowels in production and perception by Welsh-Spanish bilinguals in Argentina. Items for the task consisted of re-synthesized Welsh vowels which varied in vowel quality and duration between typical values for long and short Welsh vowel pairs.

2.1. PARTICIPANTS. Seven participants (N=5 female) who self-identified as members of the Welsh community in Gaiman, Argentina participated in the perception study. Participant ages ranged from 22 to 80, with a mean age of 39 years. One participant reported tinnitus, but their results were not excluded due to the small and exploratory nature of this study. Participants completed a language background questionnaire (Birdsong, Gertken, and Amengual 2012), which inquired about language history, use, attitudes, and proficiency and assigned each participant a language dominance score between 218 and -218, based on their responses. All participants received negative scores, indicating Spanish language dominance. Four participants were also speakers of English, and all but one had experience with English to some extent.

2.2. STIMULI. Stimuli consisted of Welsh words and non-words of the type /tVn/. This environment was chosen because stressed syllables closed by /n/ are one of the few environments where

Welsh vowel identity is not predictable by context. Orthographically, length contrasts are represented with a diacritic in unpredictable environments: *tôn* [toːn] 'tune' vs. *ton* [tɔn] 'wave'.

Recordings of a native Welsh speaker producing the vowel length minimal pairs *tîn-tin*, *tên-ten*, *tôn-ton*, and *tŵn-twn* were modified using the Praat VocalToolkit (Boersma & Weenink 2013, Corretge 2012). The vowels /i, e, o, u/ were selected for this study because they are common to both Welsh and Spanish.[2] A nine-item continuum of vowel quality was synthesized for each vowel pair, ranging in 8 perceptually equal (mel) steps between endpoints extracted from productions of target words by a native Welsh speaker (see Figure 2 for a depiction of the vowel quality continua in F1 and F2 space). A nine-item continuum of duration from 100 ms to 300 ms in 8 steps of 25 ms each was applied to each step of the vowel quality continua, resulting in 81 tokens for each tested vowel pair. Each continuum step was greater than or equal to previously reported just-noticeable differences for duration (Klatt 1976) or F1 frequency (Kewley-Port & Watson 1994).

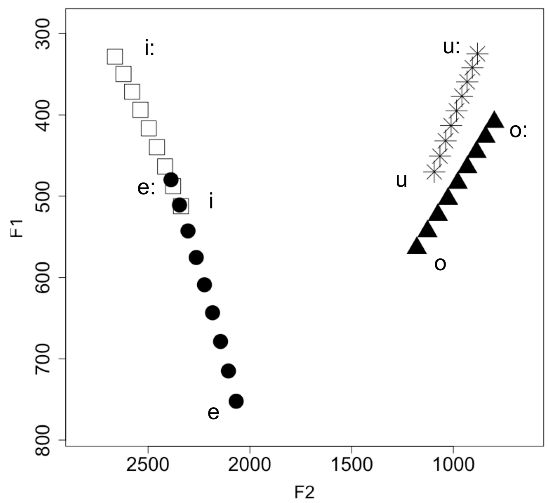


Figure 2: Synthesized quality continua for Welsh vowel pairs /i: - i/, /e: - e/, /u: - u/, /o: - o/.

2.3. PROCEDURE. Subjects participated in a quiet room at a location that was convenient to them, usually in a private home. Participants sat in front of a laptop computer running PsychoPy (Peirce 2007). Headphones were provided, but some elderly participants preferred to listen without them. The task began with a discussion of the instructions followed by a short practice period in which subjects heard unmodified tokens of the familiar Welsh minimal pair *llên* [ɬeːn] 'literature' and *llen* [ɬɛn] 'curtain', and selected the orthographic representation of the word they heard on the screen. During the practice period, feedback was given for correct and incorrect responses. Following the practice period, subjects had the opportunity to ask questions before the task began.

The task was self-paced, and divided into 4 blocks (one for each tested vowel pair), the order of which was randomized for each participant. There were 243 stimuli per block (3 repetitions of 81 unique stimuli per vowel pair). Each stimulus began with a blank screen (250 ms), followed by 500 ms of a fixation cross in the center of the screen. Response options (ex: tôn

[2] /a/, the fifth vowel common to both Welsh and Spanish was excluded from this analysis because there is little evidence to indicate that vowel quality plays a role in distinguishing /a:/ and /a/ in any dialect of Welsh (Mayr & Davies 2011).

- ton) appeared in bold face on the screen when the stimulus began to play, and participant responses were allowed beginning 250 ms after the onset of the stimulus. The visual order of the stimuli was consistent throughout the task, with the orthographically marked long vowel item always presented on the left side of the screen and the unmarked short vowel item on the right side. Participants took about 30 minutes to complete the task, including optional breaks between each block.

**3. Results.** As predicted, subjects relied on durational cues over vowel quality cues in the identification of Welsh vowels. However, the predicted effect of language dominance and age of acquisition were not present. An initial examination of the data revealed no differences between subjects' response behavior to each of the four synthesized vowels; the following analyses are based on total response rates across all of the four tested vowels.

Response rates were calculated at each step of the quality continuum (averaging over duration steps) and each step of the duration continuum (averaging over vowel quality steps), by subject. Figure 3 shows the proportion of 'long-vowel' type responses given by each subject for these two continua (averaged over all four tested vowels). Response rates hover around chance for all subjects across the vowel quality continuum, indicating that variation in vowel quality was not used as a reliable indicator of vowel identity. Near-ceiling response rates and near-floor rates were reached at the long vowel-like and short vowel-like ends of the duration continuum, respectively, indicating a strong reliance on this phonetic cue by all subjects.

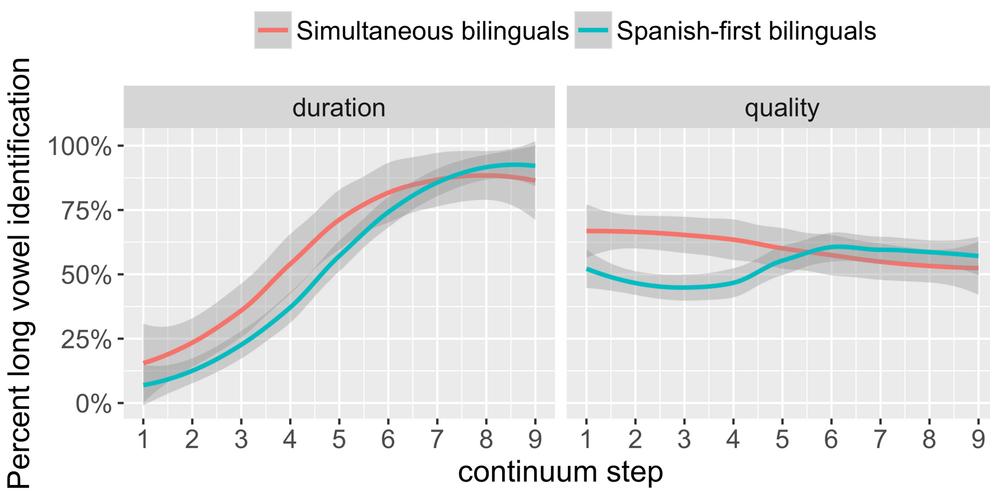


Figure 3: Percent 'long vowel' responses for each subject at each step of the vowel quality and vowel duration continua.

Based on responses to the Bilingual Language Profile questionnaire, two subject groups were created according to the order in which each participant acquired Welsh and Spanish. Those subjects who acquired Welsh as children (before the age of 12) were classified as *simultaneous bilinguals* (N=3), while those who acquired Welsh after 12 years of age were classified as *Spanish-first bilinguals* (N=3). All participants reported having learned Spanish since birth, and all were determined to be Spanish-dominant based on their final Bilingual Language Profile scores.

Two identical mixed-factor ANOVAs for the duration and vowel quality continua were conducted to determine the effect of acquisition group (between subjects: simultaneous bilinguals, Spanish-first bilinguals) and continuum edge (within subjects: long vowel-like, short vowel-like) on the percent long vowel-type responses given.

No factors were significant in the vowel quality analysis (group: F(1, 4)=1.06, $p > 0.05$, continuum step: F(1, 4)=0.341, $p > 0.05$), indicating that both groups performed at chance when stimuli varied in vowel quality. Significant effects of group (F(1, 4)=9.30, $p < 0.05$) and continuum step (F(1, 4)=54.524, $p < 0.01$) were obtained in the duration analysis, indicating that while members of both groups relied significantly on duration as a cue to vowel identity, they did so differently (see Figure 3). To further investigate differences between individual subjects, a post-hoc analysis of vowel discrimination ability was also conducted.

Z-scores were calculated for each percent long vowel-like response rate to stimuli falling at the edges of both continua, averaging over individual vowels. Because the calculation of z-scores requires accuracy percentages to fall between 0% and 100% accuracy, response values at floor and ceiling were shifted one percentage point, to 1% and 99% respectively (Macmillan & Creelman 1991).

D' is traditionally used as a measure of sensitivity to difference in discrimination tasks, calculated as the difference between the z-transformed hit rate (H) and false alarm rate (F). D' can also be used to estimate the perceptual distance between stimuli for subjects in an identification task, such as the one conducted here. Because identification tasks using a continuum of stimuli do not produce 'accuracy' rates, per se, the hit and false alarm rates were calculated using the rate at which a single response type (in this case the 'long vowel' stimulus of each pair) was selected (Iverson & Kuhl 1996). For each subject, identification rates were calculated between the 9 steps of each continuum at only the edges of the other continuum, which yielded 18 z-scores for each continuum and a total of 16 pairwise d' values for each subject.

As Figure 4 shows, pairwise discrimination across the vowel quality continuum was consistently poor across subjects, hovering around zero.

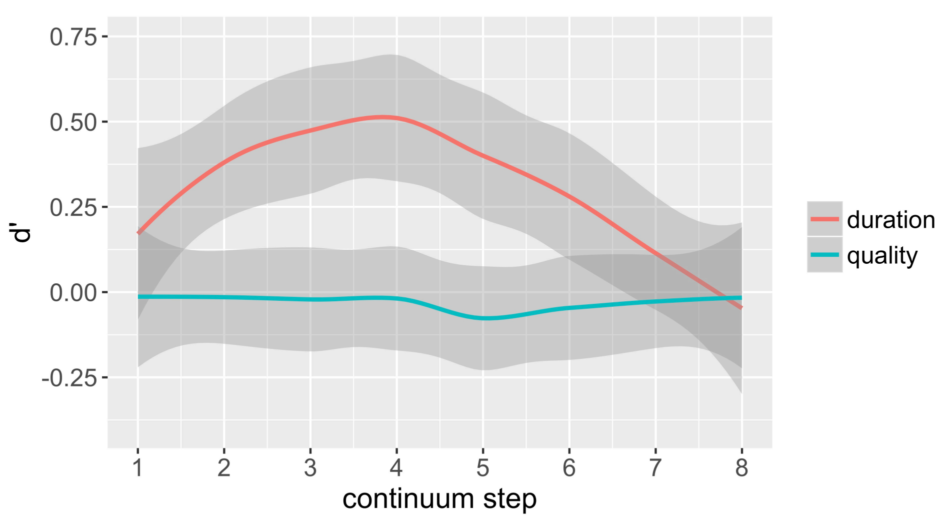


Figure 4: Pairwise discrimination of stimuli across vowel quality and vowel duration continua (all subjects).

Pairwise discrimination for the vowel duration continuum, however, reaches a peak at the pairwise comparison between stimuli 4 and 5 of the synthesized duration continuum. This peak indicates the existence of a categorical perceptual boundary between these two stimuli, at which the percentage of long vowel identification responses increases sharply.

Figure 5 presents the continuum edge d’ values for each subject. Discrimination ability between stimuli at the edges of the duration continuum was greater than that between stimuli at the edges of the vowel quality continuum. One subject (7) is a clear outlier from this pattern, and appears to use vowel quality as an inverse cue to vowel identity. That is, subject 7 consistently identified stimuli with long vowel-like formant frequencies as short vowels, and stimuli with short vowel-like frequencies as long vowels.

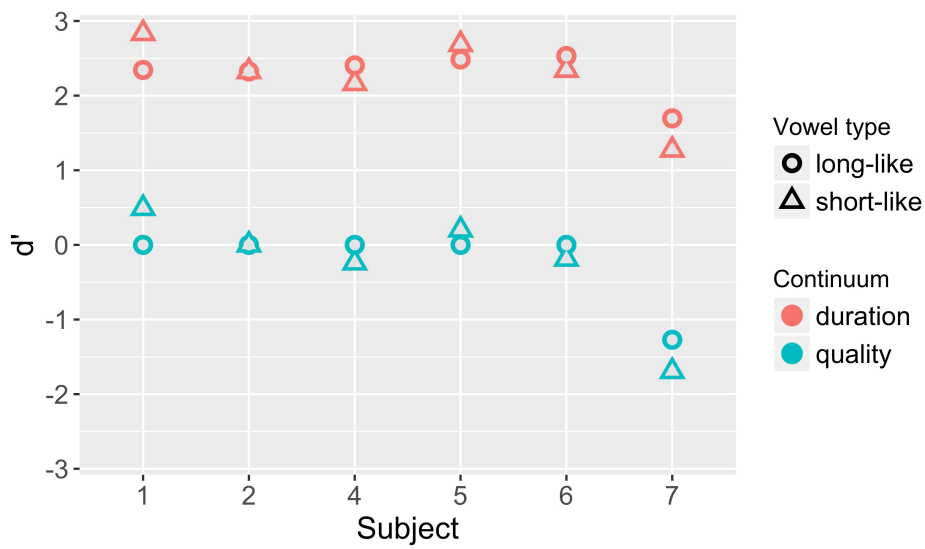


Figure 5: Comparison of d’ (discrimination ability) between continuum edges of the duration and vowel quality continua for each subject.

**4. Discussion.** Contrary to the predictions of this paper, order of language acquisition was not found to be a significant predictor of vowel identification behavior. Subjects who acquired Welsh simultaneously with Spanish performed no differently at vowel length identification than did speakers who acquired Welsh as adults. This result can likely be explained by the dominance of Spanish in the community. All participants were Spanish dominant, and no participants reported using Welsh as their primary language when conversing with family, friends, or coworkers.

The prediction that vowel duration would be a stronger indicator of vowel identity for this subject population than would vowel quality was upheld. It is apparent from the d’ analyses that the majority of participants did not exhibit a clear ability to use vowel quality differences as a cue to vowel identity. Even between the edge-most steps of the vowel quality continuum, between very long vowel-like and very short-vowel like formant values, the calculated d’ of most participants hovers around zero, indicating low discrimination ability. This is not the case for vowel duration, a cue which the majority of participants successfully used in vowel identification, as indicated by non-zero d’ values.

The size of the data set presented here does not allow for a clear conclusion to be drawn about the implications of these results for the L2LP or the other major theories of second language acquisition. However, in general terms, these results contradict the widely held assumption that age and order of acquisition affect second language acquisition; language background was not found to play a role in participants' ability to identify or discriminate L2 vowels. They also support the prediction that complete acquisition of L2 contrasts is difficult for speakers of a native language which does not rely on the relevant acoustic cues for phonemic discrimination. These results support previous work claiming the primacy of duration as a cue to vowel identity (over vowel quality) by non-native speakers (Kondaurova & Francis 2008, Flege 2007).

The conventions of Welsh orthography may have had an influence on these results. Explicit knowledge that the circumflex ˆ indicates a 'long vowel' may have predisposed listeners to rely on duration over vowel quality. However, this problem is not easily solved without introducing additional complications to the analysis. Vowel length is unpredictable in only a small subset of syllable types, and predictable in all others based on coda consonant identity. Conducting this task with word pair stimuli differing in predictable vowel length would necessarily dictate that such stimuli differed in coda voicing as well, resulting in an undesirable cofound upon which subjects might base their perceptual decisions.

**5. Conclusion.** The results presented here are atypical in that they do not demonstrate any significant effect of age or order of language acquisition on the perception of a second language. Early and late Welsh bilinguals did not differ in the perceptual cues they used to identify Welsh vowels, both groups relying exclusively on vowel duration rather than on vowel quality. Future data collection from a larger subject pool is planned, in order to clarify the data presented here. The inclusion of control data from native Welsh speakers in Wales and Spanish monolinguals in Argentina will also present two L1 baselines against which bilingual subjects' results can be compared.

## References


Awbery, Gwenllian M. 1984. Phonotactic constraints in Welsh. In Ball, Martin J. & Glyn E. Jones (eds.), *Welsh phonology*. 65–104. Cardiff: University of Wales Press.

Best, Catherine T., & Michael D. Tyler. 2007. Nonnative and second-language speech perception: Commonalities and complementarities. *Language experience in second language speech learning: In honor of James Emil Flege*. 1334. http://dx.doi.org/10.1075/lllt.17.07bes.

Birdsong, David, Libby M. Gertken, & Mark Amengual. 2012. *Bilingual language profile: An easy-to-use instrument to assess bilingualism*. COERLL, University of Texas at Austin.

Boersma, Paul & David Weenink. 2013. *Praat: doing phonetics by computer.* Computer program. http://praat.com/.

Bohn, Ocke-Schwen. 1995. Cross-language speech perception in adults: first language transfer doesn't tell it all. In Strange, Winifred (ed.), *Speech perception and linguistic experience: Issues in cross-language research*. 279–304. York Press.

Bradlow, Ann R. 1995. A comparative acoustic study of English and Spanish vowels. *The Journal of the Acoustical Society of America*, 97:1916–1924. http://dx.doi.org/10.1121/1.412064.

Corretge, Ramon. 2012. *Praat Vocal Toolkit*. http://www.praatvocaltoolkit.com.

Escudero, Paola. 2005. *Linguistic Perception and Second Language Acquisition: Explaining the Attainment of Optimal Phonological Categorization*. PhD thesis, LOT Dissertation Series 113, Utrecht University.

Escudero, Paola. 2009. Linguistic perception of "similar" L2 sounds. In Boersma, Paul & Silke Hamann (eds.) *Phonology in Perception*. 151–190. Mouton de Gruyter.

Flege, James E. 1995. Second language speech learning: Theory, findings, and problems. In Strange, Winifred (ed.), *Speech perception and linguistic experience: Issues in cross-language research*. 233–277. Timonium, Md: York Press.

Flege, James E. 2007. Language contact in bilingualism: Phonetic system interactions. *Laboratory Phonology* 9. 353–382.

Flege, James E., Ocke-Schwen Bohn, & Sunyoung Jang. 1997. Effects of experience on non-native speakers' production and perception of English vowels. *Journal of Phonetics* 25. 437–470.

Hannahs, S. J. 2013. *The phonology of Welsh*. Oxford University Press.

Harris, James W. 1969. *Spanish Phonology*. Cambridge: MIT Press.

Iverson, Paul & Patricia K. Kuhl. 1996. Influences of phonetic identification and category goodness on American listeners' perception of /r/ and /l/. *The Journal of the Acoustical Society of America* 99(2). 1130–1140. http://dx.doi.org/10.1121/1.415234.

Kewley-Port, Diane & Charles S. Watson. 1994. Formant-frequency discrimination for isolated English vowels. *The Journal of the Acoustical Society of America* 95(1). 485–496. http://dx.doi.org/10.1121/1.410024.

Klatt, Dennis. H. 1976. Linguistic use of segmental duration in English: Acoustic and perceptual evidence. *Journal of the Acoustical Society of America*. 59. 1208–1221. http://dx.doi.org/10.1121/1.380986.

Kondaurova, Maria V. & Alexander L. Francis. 2008. The relationship between native allophonic experience with vowel duration and perception of the English tense/lax vowel contrast by Spanish and Russian listeners. *The Journal of the Acoustical Society of America* 124. 3959–3971. http://dx.doi.org/10.1121/1.2999341.

Macmillan, N. A., & C. D. Creelman. 1991. *Detection Theory: A User's Guide*. Cambridge: Cambridge UP.

Mayr, Robert & Hannah Davies. 2011. A crossdialectal acoustic study of the monophthongs and diphthongs of Welsh. *Journal of the International Phonetic Association* 41. 1–25.

Peirce, Jonathan W. 2007. PsychoPy—psychophysics software in Python. *Journal of Neuroscience Methods* 162(1). 8–13.

Sebastián-Gallés, Núria & Salvador Soto-Faraco. 1999. Online processing of native and non-native phonemic contrasts in early bilinguals. *Cognition* 72(2). 111–123. http://dx.doi.org/10.1016/S0010-0277(99)00024-4.