

# FORMING NEW VOWEL CATEGORIES IN SECOND LANGUAGE SPEECH: THE CASE OF POLISH LEARNERS' PRODUCTION OF ENGLISH /i/ AND /e/

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## **Abstract**

The paper concentrates on formation of L2 English vowel categories in the speech of Polish learners. More specifically, it compares distribution of two English categories - /i/ and /e/ relative to neighbouring Polish vowels. 43 participants recorded Polish and English vowels in a /bVt/ context. First two formants were measured at a vowel midpoint and plotted on a vowel plane. The results reveal that while a separate /i/ category is formed fairly effectively in Polish learners pronunciation of English, a category of /e/ is almost completely subsumed by a Polish vowel /ɛ/

**Key words:** second language speech, vowel, L2 learning, pronunciation, acoustic analysis

## **1. Introduction**

Learners of a foreign language are faced with a difficult task of learning the sound system which is very often markedly distinct from the one they acquired for their native language. Very rarely do the spectral properties of L2 categories closely resemble those used in L1. It is therefore inevitable that, at least in the early stages, the learners will apply their existing L1 categories to produce (e.g. Flege 1987, Flege et al. 1997) and perceive (e.g. Best 1995, Best and Tyler 2007, Best et al. 2001, Flege 1995) L2 sounds. This effect of L1 on L2 appears to be especially strong for late learners of L2 (Caramazza et al. 1973, Flege et al. 2003, Guion 2003, Hazan and Boulakia 1993, MacKay et al. 2001, MacLeod et al. 2009, Piske et al. 2002).

The process of learning a vocalic system of L2 differs from learning consonants in that vowels lack a precise articulatory identity. While most consonants can be characterised by a contact of articulators somewhere in the vocal tract, vowels can only be described as approximations along two dimensions of height and frontness or backness. Moreover, the actual complexity of a vowel system in L1 is hypothesised to influence the learning of vowel system in L2 (Iverson and Evans 2009). Individuals with a large and complex vowel system are predicted to be disadvantaged in learning L2 vowels because their crowded vowel space should have less room for new vowel categories. However, this prediction seems to be as yet unresolved since vowel perception experiments have not revealed differences in performance by listeners with

more and less crowded L1 vowel spaces (Iverson and Evans 2007) and some research has suggested that the fact that an L1 vowel system has a small number of categories does not necessarily imply that the remaining acoustic space is not committed (Meunier et al. 2003).

Both current models of non-native speech production and perception – the Perceptual Assimilation Model (PAM) (Best 1995, Best and Tyler 2007) and the Speech Learning Model (SLM) (Flege 1995) assume that the phonetic similarities and dissimilarities between L1 and L2 segments will influence the degree of success in producing non-native sounds. Phonetic similarity or dissimilarity is defined in terms of the articulatory and acoustic characteristics of the linguistically relevant speech sounds. PAM concentrates on how monolingual speakers of one language perceive sounds from an unfamiliar language. The resemblance of L1 and L2 sounds is based on articulatory properties used in their articulation. L2 categories most similar to L1 categories will be perceptually assimilated, thus leading to confusion. On the other hand, if L2 categories are sufficiently different, they will be perceived as uncategorizable speech sounds.

More relevant to the present study are predictions made by SLM because SLM, unlike PAM, addresses the question of learning and concentrates on highly experienced learners. The actual attainment of native-like pronunciation of given L2 sounds is also assessed relative to the phonetic distance between L2 and L1 segments. Learners are hypothesised to be less successful in learning L2 sounds that are perceived as similar to L1 sounds because this similarity will block the phonetic category formation by means of the perceptual mechanism of equivalence classification. In contrast, L2 sounds perceived as new or different from L1 categories will motivate the learners to develop new L2 categories. According to SLM, learners who aim to achieve native-like production in a second language must not only have an accurate understanding of the properties that differentiate the sound categories in this language but also must store and structure this information in the long-term memory and must learn articulatory patterns to accurately produce L2 sounds (MacLeod et al. 2009). This hypothesised tight coupling between perception and production has been confirmed by research with a statistical pattern approach to measuring cross-linguistic similarity (Thomson et al. 2009).

## **2. Previous research on English /ɪ/ and /e/ in second language speech**

A great bulk of previous research on English /ɪ/ has focused on its perception and production with reference to tense /i:/. Spanish learners of English, whose native language has a vowel /i/, which is roughly intermediate between English /i:/ and /ɪ/ (Bradlow 1995, Flege 1989), classify a vowel /ɪ/ as an instance of either Spanish /i/ or /e/ (Flege 1991). In another study, Spanish learners judged English /ɪ/ and Spanish /i/ to be more dissimilar than English /i:/ and Spanish /i/ (Flege et al. 1994). In a task in which native speakers of English identified productions of /i:/ and /ɪ/ from Spanish learners, only a few Spanish participants were found to differentiate English contrasts correctly (Flege et al. 1997). A similar pattern of an /i:-/ɪ/ acoustic and perceptual merger has been found for other languages such as Mandarin (Thomson et al. 2009), Korean (Flege et

al. 1997), Norwegian (Iverson and Evans 2007), or Serbian (Krebs-Lazendic and Best 2007). Instead of relying on spectral properties of an /i:/-/ɪ/ contrast, L2 learners exploit and exaggerate durational values of those vowels, in that /i:/ is longer than /ɪ/, the feature which is redundant or secondary for native speakers. This regularity has been observed for speakers of Spanish, Mandarin, Portuguese, Polish, Japanese, Russian, and Catalan, even though none of these languages uses vowel duration differences contrastively (Escudero et al. 2009). The reasons for this reweighting of perceptual cues are still unclear. It is suggested to result from the fact that L2 learners of English are explicitly taught durational differences between tense and lax vowels (Flege et al. 1997, Wang and Munro 1999), the learners' focus on duration as psychoacoustically highly salient (Bohn 1995), the learners' allophonic experience with duration in their native language (Kondaurova and Francis 2008), or from the fact that these learners have never used duration contrastively in their native language and, therefore, can create a contrasting mechanism along this dimension (Escudero and Boersma 2004, Escudero et al. 2009).

The research on a vowel /e/ in second language speech has concentrated on its relation to /æ/ both in production and perception. Flege et al. (1997) found that German learners, unlike Spanish learners, had difficulties recognising the contrast between /e/ and /æ/ because the German groups assimilated this contrast to only one /ɛ/ category in their native language, whereas the Spanish grouped instances of those two English vowels into their native /e/ and /a/. Although SLM hypothesises that the distinction between /e/ and /æ/ will not be problematic for learners whose L1 uses /e/ and /a/, this has not been confirmed with Serbian (Lazendic and Best 2007) and Brazilian (Barboza 2007) learners. As in the case of an /i:/-/ɪ/ contrast, those learners relied primarily on durational differences between the two vowels rather than on their spectral properties.

### 3. Current study

In the current study, we use a method of measuring cross-linguistic similarity of vowels in L1 and L2 (Bohn and Flege 1992, Flege 1995) produced by Polish learners of English in order to determine the extent of overlap between the spectral properties of vowels in L1 and L2 matched for their similarity. Unlike English, Polish has a lightly dense vowel system because it uses only six oral vowels (Jassem 2003). Figure 1 shows a schematic plot of six Polish vowels (dots) with overlaid English /ɪ/ and /e/ (squares).

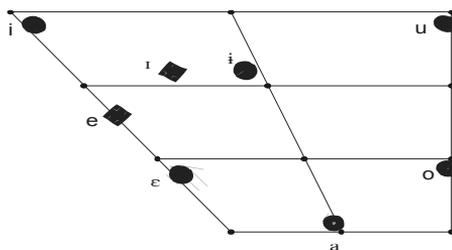


Figure 1: A schematic plot of overlaid Polish vowels and English /ɪ/ and /e/.

The inspection of a plot reveals that the position of English /ɪ/ and /e/ will present two different scenarios for their acquisition by Polish learners. The vowel /ɪ/ lies roughly intermediate between Polish /i/ and /i/ in the high area of the plot. The vowel /e/, on the other hand, shares the mid-low area with Polish /ɛ/ but is noticeably higher. Using the SLM metric, it is predicted that English /ɪ/ will be assimilated by either Polish /i/ or /i/, whereas English /e/ will be completely assimilated by Polish /ɛ/.

Previous research on the Polish learners' production of English /ɪ/ and /e/ is very scarce and based only on auditory impressions. Sobkowiak (2001) notes that, in the early stages, Polish learners tend to identify English /ɪ/ directly with Polish /i/. In the case of /e/, they are observed to consistently substitute it with Polish /ɛ/. Nowacka (2010) used a longitudinal study in order to tap the developmental changes in Polish learners' production of English vowels and consonants. Twenty five subjects were recorded first when entering the college and after the period of three years before graduation. Relevant to the current study, the participants in this study were advanced users of English, at least during the second recording before graduation. The results revealed that there was no improvement in vowel quality either for /e/ or /ɪ/. While the lack of progress for the former vowel is in agreement with our hypotheses, the fact that the vowel /ɪ/ did not emerge as a separate category stands in contrast to our predictions. It should be noted, however, that the methodology in this study was based on goodness ratings obtained from five teachers of English phonetics, the author included, rather than spectral measurements. This methodology has been found to suffer from serious inadequacies (Baker and Tromifovich 2005, MacLeod et al. 2009, Thomson et al. 2009), which may have influenced the results. Finally, Bogacka (2004) tested Polish learners' perception of the /i:/-/ɪ/ contrast as a function of spectral properties and duration. She used a /hi:d-/ /hid/ continuum recorded by a qualified phonetician and subsequently manipulated to vary in durational steps. Unlike native English subjects, Polish listeners relied strongly on durational cues and no spectral properties, as revealed by their identification pattern. Longer values were consistently associated with /i:/ despite the actual spectral characteristics of a stimulus. It should be emphasised, however, that the participants of this study did not match the participants of the current study, in that Bogacka (2004) recruited high school students, which makes it unlikely that they were all proficient speakers of English.

In summary, we put forward the following two different scenarios concerning the production of English /ɪ/ and /e/ by Polish advanced learners.

1. The category for English /ɪ/ will be effectively formed since it will dissociate from both Polish /i/ and /i/. Although initially English /ɪ/ will be assimilated by Polish /i/, with increasing proficiency, the learners will notice that /ɪ/ does not resemble either /i/ or /i/, but rather that it merges the spectral properties of both Polish vowels. That will provide sufficient motivation for the formation of a new L2 category
2. The category for English /e/ will not be formed, but rather this vowel will be wholly assimilated by Polish /ɛ/. The learners will not direct their attention to the fact that the English vowel is higher than a corresponding vowel in their native language. Because the use of Polish /ɛ/ instead of English /e/ will not seriously

impair the communication, there will be no pressure, and hence no motivation, for the formation of a new category.

### 3.1. Participants

A total of 43 subjects participated in the study: 31 females and 12 males. They were recruited from third-year students at the Institute of English, University of Silesia. This selection guaranteed a uniform level of proficiency due to a regular administration of various tests in use of English. They considered themselves to be advanced speakers of English with no difficulties in communication with native speakers. They had been given 120 hours of explicit phonetic training in English pronunciation in the first and second year. They ranged between 21 to 29 years of age (mean: 21.3, median: 21). Eighteen participants reported to have spent more than a month in an English-speaking country. They all volunteered and were not paid for their participation. None of the subject reported any speech or hearing disorders.

### 3.2. Materials

All vowels were embedded in a /bVt/ context. In two separate sessions, both Polish and English vowels were recorded. All Polish vowels were needed as corner landmarks in order to establish an acoustic space for each speaker, which is necessary for a normalization procedure. We could not use a standard /hVd/ context (Peterson and Barney 1952) because while English uses a glottal fricative /h/, Polish has a velar /x/ (Jassem 2003). This would have made vowels from both languages incomparable due to the fact that consonantal effects may persist throughout the whole vowel portion, including its target (Fox and Jacewicz 2009).

The target /bVt/ words were embedded in carrier sentences *I say /bVt/ this time* in English and *Mówię /bVt/ tym razem* in Polish in a non-utterance final position. This position was preferred because previous research has demonstrated a significant impact of utterance final positions on spectral properties of different sounds (Cho 2004, Edwards et al. 1991, Fougeron and Keating 1997, Turk and Shattuck-Hufnagel 2000).

### 3.3. Procedure and recording

All recordings were made in a quiet room. English and Polish words were recorded in two separate sessions separated by 4 hours. In order to avoid a language-first effect, one half of the participant recorded English first and the other half started with Polish. Each word from every speaker was recorded twice. Both recording sessions took about fifteen minutes each. In order to ensure that the speakers would be in the desired language mode (Escudero et al. 2008, 2009, Grosjean 2001, Kroll and Sunderman 2003, Marian and Spivey 2003), the experimenter held a five-minute conversation with each participant in a target language prior to the recording.

The carrier sentences were presented graphically on separate sheets for English and Polish. Although only two English vowels are analysed in this study, all vowels were recorded from each speaker for other research projects. Special care was taken to instruct speakers to produce the sentences as if speaking to a native speaker (Strange et al 2009) and to avoid unnecessary pauses and hesitations.

The carrier phrases with /bVt/ words were recorded with a Media Tech MT385 USB microphone with a flat response between 100 and 16000 Hz positioned 10 centimetres from a speaker's mouth. The speech input was processed and recorded by an external Sound Blaster X-Fi X-MOD sound card with a 24 bit sampling rate, frequency range 140 – 20000 Hz, and sensitivity 112 dB +/- 3 dB. The recordings were sampled at 44.10 kHz (24 bit accuracy) and subsequently stored in a notebook hard drive memory as a WAV file ready for inspection.

### **3.4. Acoustic measurements**

Prior the measurement session, all recordings were downsampled to 11.025 Hz and a Praat 5.1.17 speech-analysis software package (Boersma 2001) was used to scroll through the audio files in order to locate an onset and offset of target vowels. Frequencies of F1, F2 and F3 were measured at vowel mid-point, where the moment of formant movement is minimal, so as to avoid transition movement from and to the neighbouring consonants (Hillenbrand et al. 2001).

Formant frequencies were computed with a 25-ms Hanning window with a default 14-pole LPC (linear predictive coding) prediction order, using add-on vowel analysis software Akustyk 1.8 (Plichta and Preston 2004). If the automatic analysis yielded clear errors (spurious formants or missed formants), LPC spectral envelopes and FFT (fast fourier transform) power spectra were compared in order to recompute a prediction order so that it would match a particular speaker's voice quality. The total number of analysed tokens was (6 Polish vowels + 2 English vowels) x 43 speakers = 344.

The raw measurements were subsequently normalised using the Lobanov transform (Lobanov 1971), which was found to perform exceptionally effectively in reducing anatomical and physiological variation between speakers while preserving phonemic identity in the acoustic measurements (Adank et al. 2004).

### **3.5. Analysis and results**

Normalised frequencies of the first and second formants of analysed vowels from all speakers were scatter plotted along F1 and F2 axes.

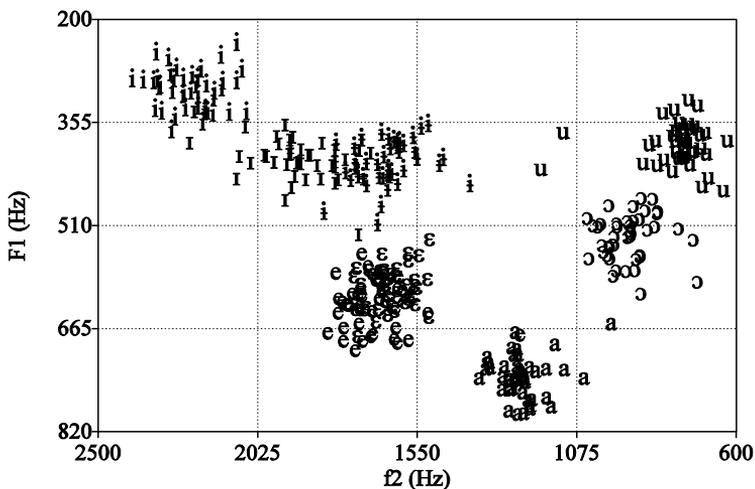


Figure 2: Scatter plot in Hz of 6 Polish and 2 English vowels

Next, in order to identify separate sound categories and to observe how they interact with each other, we used a Principal Component Analysis (PCA), which transforms a number of possibly correlated variables into a smaller number of uncorrelated variables. Figure 3 shows the distribution of vowel categories demarcated by ellipses.

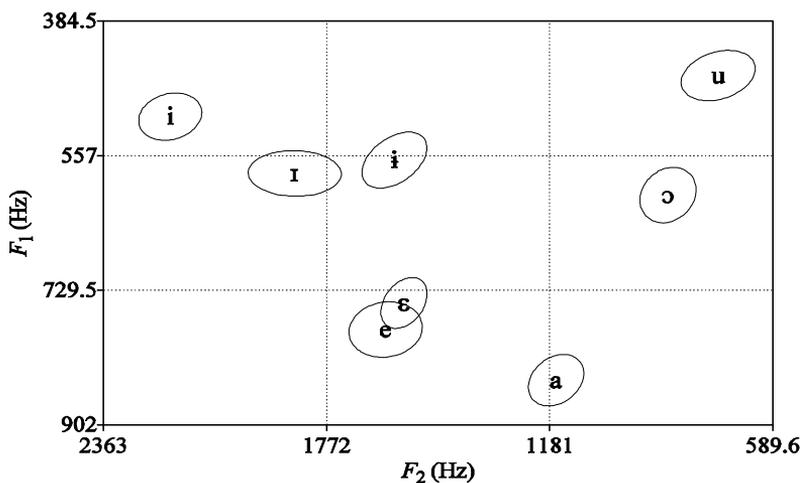


Figure 3: Distribution of vowel categories computed with Principal Component Analysis (PCA).

Figure 4 shows mean F1 and F2 frequencies (solid lines) with their standard deviations (dotted lines) plotted on a vowel plane. Table 1 shows numerical values of F1 and F2 frequencies and standard deviations for English /ɪ/ and /e/ and Polish /i/, /ɨ/ and /ɛ/.

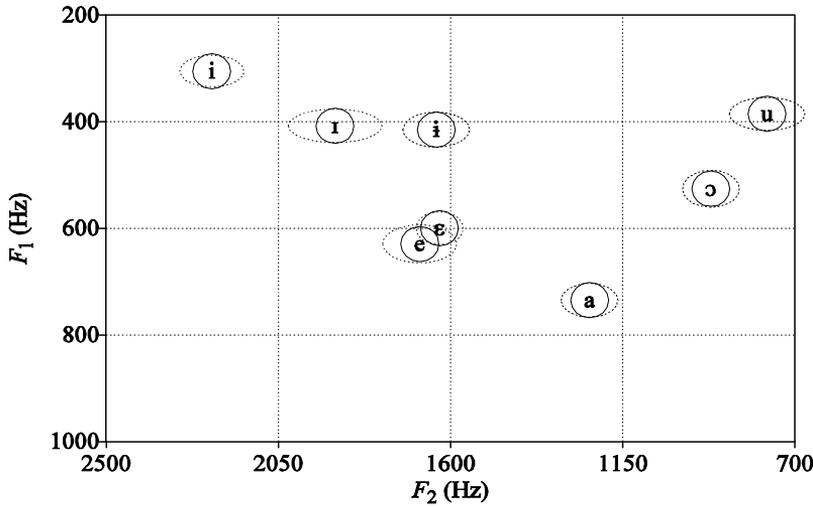


Figure 4: Mean frequencies in Hz of F1 and F2 (solid lines) and their standard deviations (dotted lines)

Table 1: Numerical values of mean formant frequencies and their standard deviations for Polish /i/, /ɨ/ and /ɛ/, and English /ɪ/ and /e/

vowel	F1	F2	F1 std. dev.	F2 std. dev.
POL /i/	304	2223	29.82	83.64
POL /ɨ/	414	1637	33.08	87.20
POL /ɛ/	599	1628	31.02	62.04
ENG /ɪ/	407	1901	31.58	122.69
ENG /e/	628	1680	35.75	97.03

The analysis reveals two different developmental scenarios for English /ɪ/ and /e/ in relation to Polish vowels in Polish learners' pronunciation of English. It is evident from F1-F2 planes that a new category for English /ɪ/ has emerged between Polish /i/ and /ɨ/. Both the PCA analysis and the mean-frequency plot show that it occupies a separate territory in the acoustic space of Polish learners and is not subsumed by any of the neighbouring Polish vowels. The computed Euclidean distance (i.e., root mean square) in Hz indicates that English /ɪ/ is located 338 Hz from Polish /i/ and 264 Hz from /ɨ/. These distances suggest that the category for this vowel has been established optimally as a merger of acoustic properties of two neighbouring Polish vowels. The inspection of

standard deviations for its F2 frequencies shows high variability along an F2 axis across individual speakers. This may be taken to mean that, although the speakers have dissociated a target category for English /ɪ/ from neighbouring Polish /i/ and /i/, this new L2 category is not stable, but rather it is constantly under the influence of a magnet effect from L1 categories.

The results obtained for English /e/ with reference to Polish /ɛ/ indicate almost complete assimilation of an L2 category by a category in L1. There is a significant overlap between L1 /ɛ/ and L2 /e/, at least for some part of the space occupied by these two vowels. The Euclidean distance separating these two vowels is only 60 Hz. It is also interesting to note that the locus of English /e/ is even lower than the one of Polish /ɛ/. This lowering of /e/ with reference to /ɛ/ is against the expected target productions of /e/ which are observably higher along the F1 axis than the values for /ɛ/. It points to the conclusion that the speakers not only failed to establish a separate category for /e/ but they also tend to move it in a different direction. This unexpected slight dissimilatory downward movement may be explained by acquisitional factors related to perceptual salience of acquired L2 sounds. As noted by Sobkowiak (2001), Polish learners tend to substitute /e/ with /æ/, which has its source in a hypercorrection pattern according to which Polish learners consider English /e/ to sound 'too Polish' and choose to use /æ/ instead. We may have captured this process in the current data, which may explain the unexpected lowering of /e/ relative to /ɛ/. However, it is unlikely that this substitution pattern should have occurred for all speakers, because the lowering is not great, 60 Hz of a Euclidean distance from /ɛ/. A more consistent substitution pattern would have resulted in a strong pull towards higher F1 values or even towards the space occupied by Polish /a/.

#### 4. General discussion

In the current paper, we set out to analyse the quality of L2 English vowels /ɪ/ and /e/ in relation to L1 Polish /i/, /i/, and /ɛ/ in productions of advanced Polish learners of English. Using the metric of the Speech Learning Model (Flege 1995) we predicted two different scenarios for the acquisition of English /ɪ/ and /e/. In the case of /ɪ/ it was hypothesised that this vowel would be perceived as different from Polish /i/ and /i/, which will motivate the learners to establish a new L2 sound category. The learners will use two neighbouring L1 vowels as acoustic coordinates and the new L2 category will emerge as a merger of their acoustic properties. On the other hand, English /e/ was predicted to be perceived as similar to Polish /ɛ/, which would result in its being assimilated by a native category. In this case, the learners will not be sufficiently motivated to create a new L2 category and the quality of English /e/ will obtain similar values to the ones obtained for Polish /ɛ/. In order to verify the two scenarios, we recorded advanced speakers of English producing target vowels in a /bVt/ context in carrier sentences and measured their formant frequencies.

Both hypotheses have been confirmed in our results. Two different scenarios were evident in the analysis. English /ɪ/ dissimilated from Polish /i/ and /i/ as a separate

category occupying non-overlapping acoustic space. Although this category is not stable, as demonstrated by relatively great standard deviations for F2, it is observably distinct from, and not subsumed by, any of the neighbouring L1 vowels. An opposite pattern has been found for English /e/ relative to Polish /ɛ/. Here, the speakers failed to dissimilate a new vowel category from an L1 category, even though a cross-linguistic comparison indicates that English /e/ is significantly higher in vowel space than Polish /ɛ/. Moreover, the productions of /e/ seem to be located slightly lower than the productions of /ɛ/, which adds to the conclusion that the category of /e/ has neither been created nor its target has been located. However, as previously noted, this unexpected lowering may be explained by a hypercorrection pattern in which Polish learners occasionally substitute /æ/ for /e/ because the former is found by them to be 'more English' (Sobkowiak 2001). If the learners find /e/ to sound 'too Polish' it gives additional support to our conclusions that English /e/ is completely subsumed by Polish /ɛ/.

The current results are in contrast to the results obtained in previous studies with Polish learners. Nowacka (2010) reported that the quality of English /ɪ/ in Polish learners' pronunciation does not improve despite explicit phonetic training. Although the proficiency level of participants in this and the current study is comparable, there are gross methodological differences between the two studies, in that Nowacka used auditory ratings from teachers of English phonetics and no acoustic analysis was performed. Bogacka (2004) used a six-step continuum between English /i:/ and /ɪ/ to test Polish learners' perception of this contrast as a function of spectral cues and duration. The author concluded that the listeners relied on spectral cues significantly less than native listeners. Considering the evidence that underlying perceptual categories may reflect production ability (Flege 1995, Thomson et al. 2009), it may be taken as evidence that the participants in this study did not have a fully developed category for /ɪ/. However, as already mentioned, the listeners in her study were high school students, which makes it unlikely that they all matched in proficiency participants in the current study, who were recruited from university students of English. Whether the role of proficiency in /ɪ/ production is a crucial factor still remains largely unresolved. Although (Jun and Cowie 1994) found that experienced Koreans produced English /ɪ/ more accurately than did the less experienced Koreans, Flege et al. (1997) did not observe an impact of experience on production accuracy of an /i:/-/ɪ/ contrast by Korean and Spanish subjects.

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