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# The effect of language proficiency on the perception of segmental foreign accent

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## Abstract

Foreign accent has different effects on speech intelligibility for native and non-native listeners. However, not much is known about the impact of individual foreign-accented segments on listeners with different levels of proficiency in the language. Using a technique developed to generate degrees of segmental foreign accent, this study investigates how native and non-native listeners differing in language proficiency categorise and discriminate degrees of accentedness at the segmental level. Listeners responded to continua ranging from Spanish-accented tokens to English tokens, constructed by inserting accented segments into words. Six continua were chosen, based on known problems faced by Spanish speakers of English. Whether foreign accent categorisation performance differed across native and non-native listeners was found to depend on the status of the segment in the listeners' first language. For certain sounds both high and low proficiency non-native groups resembled native listener responses. For other sounds, categorisation revealed a clear effect of proficiency, with the high-proficiency group closer to native performance than the low proficiency cohort. This behaviour indicates an ongoing process of new second language phonemic category creation by the more proficient learners.

**Index Terms**: non-native speech, segmental foreign accent, foreign accent perception, listener proficiency, speech gradation

## 1. Introduction

Non-native (NN) pronunciation typically differs from native (N) speech due to influences from a speaker's first language (L1). These differences manifest themselves both segmentally [1] and suprasegmentally in properties such as speech rate [2], duration [3] and nuclear stress [4]. Taken together, such differences result in a foreign accent (FA). The focus of the current study is on the segmental contribution to FA, making use of a recent technique to isolate the segmental component of FA [5] from potential higher-level contributions to the perception of accent.

The effects of FA on N listeners in terms of intelligibility, comprehensibility and perceived nativeness have been widely investigated [6, 7, 8, 9]. Such studies have typically used N judges, based on the assumption that they are better at identifying FA than NNs, although some studies have found comparable capabilities in the detection of FA between N and NN judges [10]. Nevertheless, there is a body of literature that suggests that N and NN listeners do not perceive FA in the same way [11, 12, 13, 14, 15] due to different cue use dependent on their native language [16]. The first question we address here is whether N and NN listeners behave similarly when categorising and discriminating FA isolated at the segmental level.

The division between N and NN listeners can also be approached in broader terms as a question of listener proficiency in the target language. The role of listener proficiency in accented speech has generally been studied in terms of overall intelligibility and segment identification, with mixed findings. For N listeners, NN speech is usually less intelligible than N speech [11, 12, 13, 15, 17] unless the NN speech comes from highly proficient speakers [18]. NN listeners sharing the same L1 as NN speakers have been found to benefit from FA in terms of overall speech intelligibility but only if their proficiency in the target language is low [11], while NN listeners with a higher proficiency level tend to find FA *less* intelligible [13, 18, 19, 15]. Our second goal is to explore how high and low NN listener proficiency affects FA judgements at the segmental level.

In the current study three distinct cohorts of listeners – native English, native Spanish with high proficiency in English, and native Spanish with low English proficiency – judged stimuli as native- or foreign-accented. Each stimulus was an English word with one consonant replaced by a segment whose degree of FA had been modified. Stimuli were constructed from six continua, one per consonant, each being a sequence of realisations of a single word in which the accentedness of the target segment varied from fully-non-native at one end of the continuum to fully-native at the other end. Listeners also undertook a discrimination task involving same or different realisations from these continua.

## 2. Methods

### 2.1. Participants

The native group (16 listeners, mean age 25.9 years) was tested at the University of Edinburgh and (i) had English as their first language, with their main experience in English acquired in the UK; (ii) were not bilinguals in any language; and (iii) had no knowledge of Spanish. The two Spanish cohorts were tested at the Alava campus of the University of the Basque Country. These listeners (i) had Spanish as a first language; (ii) had no significant competence in any other foreign language apart from English; and (iii) had reached a certain proficiency level in English. Participants with A1-A2 proficiency were assigned to the low proficiency group (LP, 20 listeners, mean age 21.1), while those with B2-C1 were assigned to the high proficiency group (HP, 13 listeners, mean age 18.5).

### 2.2. Stimuli

Six target English consonants in word initial position (Table 1) were chosen based on known problems faced by Spanish-speaking learners of English. The sounds [h] and [ɹ] were selected because of the saliency of their mispronunciations; [v], [j], and [ʤ] were chosen for the high confusion potential of their typical mispronunciations, while [$t^h$] was included as a representative of a well-known realisational difference between



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| Foreign-accented | Native-accented | Words |
|---|---|---|
| r | ɹ | rainbow, reason |
| j | ʤ | gipsy, gender |
| ʤ | j | user, yours |
| x | h | hammer, happen |
| t | $t^h$ | tea, type |
| b | v | veil, vanish |

Table 1: *Consonant continua and corresponding words tokens.*

the two languages. Two exemplar words per consonant were deemed sufficient based on an earlier finding [5] of an absence of an effect of word exemplar for the type of segmental FA manipulation employed here.

For each of the 12 words, a 9-step continuum was generated between the foreign-accented and native segments shown in Table 1, using a procedure introduced and described in detail in [5], and which is summarised here. The aim of the gradation technique is to produce a series of words that differ in the degree of foreign-accentedness of a single segment (here, the word-initial consonant). The technique makes use of speech material (words and non-words) spoken by an advanced bilingual with no discernible accent in either language. The starting point is to excise the native segment from the target word, and extract a corresponding foreign-accented segment from a non-word in a similar phonetic context as the target word. Then, for each position along the continuum, the native and foreign-accented segments are blended to produce a new segment with graded accent. Blending involves weighting the segments for durational differences, followed by a weighted sum at the waveform level, with weights determined by position along the continuum. Fundamental frequency and speech level are normalised to remove artefacts prior to reinsertion of the new segment in the target word. Examples of spectrograms resulting from tokens at each point of two such continua are shown in Fig. 1.

One expert in each of English and Spanish phonetics listened to all continua to check for inconsistencies, artifacts or other anomalies. In one case only, that of the continuum involving [ʤ] and [j], the $f_0$ curve needed to be adjusted manually after the stimuli were generated.

### 2.3. Tasks

Participants carried out (i) a categorisation task, which provided information on the relationship between degree of accent manipulation and categorisation as *Native* or *Foreign*; and (ii) a discrimination task, to determine the point of maximum discrimination between steps of the continuum.

#### *2.3.1. Categorisation*

The categorisation task was a two-alternative forced choice test in which listeners had to decide whether the word heard was pronounced with a native or a foreign accent. Users responded by pressing one of two buttons labelled 'Native' and 'Foreign'. Listeners heard stimuli in a quasi-random order, with the only constraint being that no stimulus came from the same continuum as the preceding stimulus. All steps of each continuum were presented once, apart from the native extreme (step 9), which appeared 3 times in order to reduce any numerical bias towards foreign-accented stimuli (since all points along the continuum apart from the native end can in principle be considered as accented). Listeners were encouraged to choose the answer

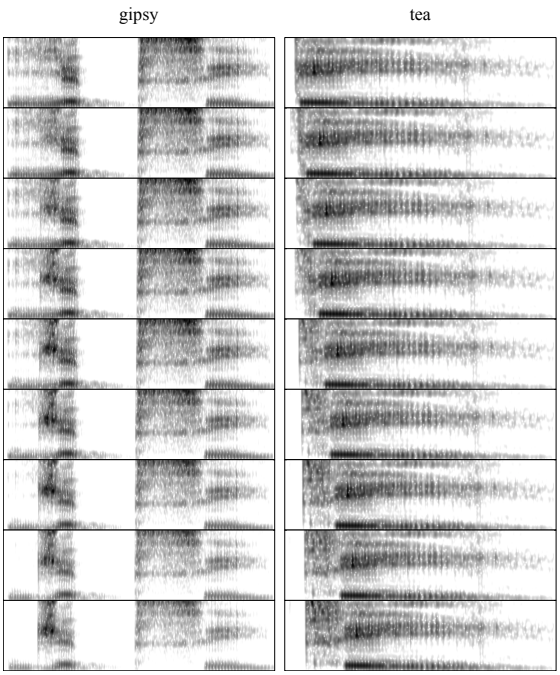


Figure 1: *Spectrograms for 9-step continua of the words "gipsy" and "tea" from foreign-accented (top) to native (bottom).*

that best fitted their perception rather than aim for an equal number of 'Native' and 'Foreign' categories.

Listeners were able to see the word they were listening to spelled out on the screen, in order to avoid a Ganong effect [20] or confusion with a possible minimal pair. An example of the latter case is the word *banish*, which can be rated as *Native* as it is an existing word in English. By showing the word *vanish* as the target, the user can disambiguate and identify [baniʃ] as an accented representative of the word *vanish*. Listeners underwent a five-stimulus practice session with stimuli from a [d]→[ð] continuum generated using the same procedure as the main experiment. Participants were informed that each stimulus would be available to hear only once, and could not be repeated. The full set of stimuli was presented four times, leading to a total of 528 tokens (6 continua × 2 words × 11 steps × 4 repetitions). Participants had a 60 s break every 132 trials. The task required 9.7 minutes on average.

#### *2.3.2. Discrimination*

The discrimination task had an AX format in which listeners had to decide if two stimuli were the same or different by clicking on one of two buttons with these labels. In each *Different* pair trial, the stimulus consisted of a word at a randomly-selected step along the continuum and the same word either two steps up or two steps down the continuum. Control *Same* pairs were also introduced. The order of the stimuli in the experiment followed the same pseudo-random strategy as in the categorisation task. Each pair appeared three times for a total of 828 trials (12 continua × 23 pairs × 3 repetitions). The interval between each one of the two steps presented per trial was 0.5 s and there was a 60 s pause every 276 trials. Unlike in the categorisation task, listeners did not see the orthographic form of the word. Again, listeners were instructed not to think about this task in-

volving equal numbers of same and different pairs, and were encouraged instead to choose the answer that best suited their impression. A practice session was included, consisting of five trials from a [d]→[ð] continuum. The task took 30 minutes to complete on average.

To avoid familiarisation with the orthographic forms prior to the categorisation task, the discrimination task was presented first. The experiment was run using the standard experimental interface provided by Praat [21]. The experiment took place in individual sound-attenuating booths using the same headphone model (Sennheiser HD-380 Pro) at each of the two sites.

# 3. Results

## 3.1. Preliminaries

Following [17], a small proportion of responses (under 1% for each task) with reaction times outside the range [300, 5000] ms were removed from the analysis. Data reduction and statistical analyses were performed using R [22]. Generalised linear mixed models (GLMM) were constructed using function `lmer` from the `lme4` package [23]. A GLMM of the form $cohort \times segment \times direction$ with listener as a random effect was constructed to compare upwards and downwards trials. Although $direction$ was a significant effect, a pairwise least-squares means test revealed the factor to be significantly different only for English listeners in the [x]→[h] continuum; consequently, a decision was made to remove the $direction$ factor from the model for subsequent analyses.

Pairs in which the same step of the continuum was presented twice were also analysed. The English group noticed no differences 93% of the time. The Spanish HP group considered such pairs as identical on 88% of the presentations, while the equivalent figure was 87% for the Spanish LP cohort. A 3-sample test for equality of proportions without continuity correction revealed no significant differences between the three groups regarding the correct discrimination of the *Same* trials. While chance discrimination performance *a priori* is 50%, to accommodate differences in the number of *Same*/*Different* trials, an adjusted *a posteriori* chance performance was computed based on the ratio of observed *Same* and *Different* responses.

Differences in responses to words involving the same segment continua were also analysed. A significant difference was found only in responses from English listeners between the words *veil* and *vanish* (i.e. the [b]→[v] continuum), specifically in steps 5, 6 and 9 [$p < .001$]. As a result, words from the same continuum were analysed jointly.

## 3.2. Overall accent ratings

Averaged across consonants, nativeness categorisation differed among the three cohorts (Fig. 2), particularly in the judgement of tokens at the foreign-accented end of the continuum, where the greater the cohort's experience in English, the more likely tokens were to be judged foreign-accented. Discrimination performance was very similar for the three cohorts. A GLMM with $step$ and $cohort$ as fixed factors and listener as a random factor revealed a significant effect of $step$, $cohort$ and their interaction [all $p < .001$]. A post-hoc pairwise least-squares means test pinpointed significant differences between Spanish LP listeners and N listeners in steps 1-6 of the continuum, while the Spanish HP group differed from the native group in steps 1-3. A similar GLMM for the discrimination task suggested a $cohort$ effect [$p < .05$]. The post-hoc pairwise test revealed a difference between N and LP groups at step 4 [$p < .05$].

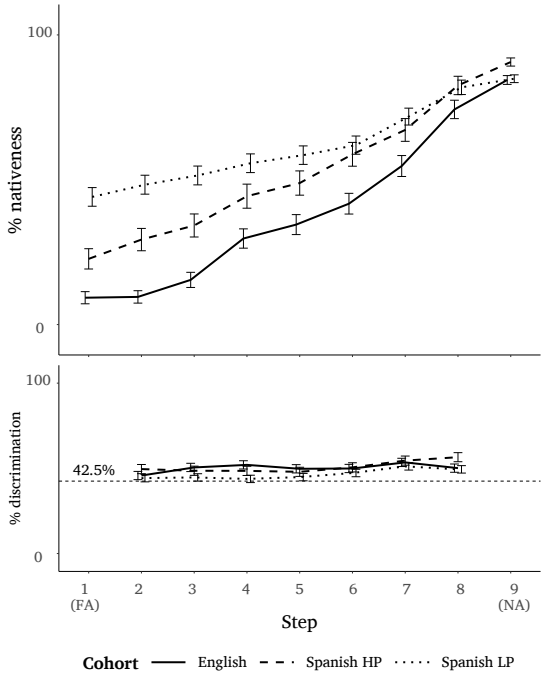


Figure 2: *Mean categorisation (top) and discrimination (bottom) responses in a foreign (FA)-to-native (NA) continuum for the three experimental cohorts. Here and elsewhere vertical bars represent* $\pm 1$ *standard error. The horizontal line at 42.5% indicates the a posteriori chance level (see text for details).*

## 3.3. Per-segment accent assessment

At the level of individual segments (Fig. 3) the three cohorts showed broadly similar categorisation responses for [x]→[h], [r]→[ɹ] and [t]→[t$^{h}$] but differed for the remaining continua. English listeners judged the entire [b]→[v] continuum as less native than the other cohorts [$p < .001$]. For both [j]→[ʤ] [$p < .01$] and [ʤ]→[j] [$p < .001$] responses varied across cohorts: Spanish LP listeners perceived these two continua as native regardless of the step (and showed a commensurately flatter discrimination profile), while Spanish HP listeners were more like N listeners but perceived tokens as more native-like.

As expected, maximum discrimination performance typically occurred at the point in the continuum where perception could be considered as shifting from one category to another (Fig. 3). However, this relationship was clearer for N listeners and the HP Spanish cohort, whereas the Spanish LP group exhibited uniformly poorer discrimination in spite of showing a change in nativeness categorisation across the continua. A closer inspection revealed that the main difference between the Spanish LP cohort and the other groups was not that the former were unable to discriminate, but rather that the point along the continuum representing the boundary between categories was identified less consistently within the LP group.

# 4. Discussion

Foreign-accented speech has traditionally been found to be less intelligible than native-accented speech for N listeners, whereas for some NN listeners FA can be of equal or greater intelligibility [12, 24, 25]. The first goal of the current study was to determine whether N and NN listeners also differ when categoris-

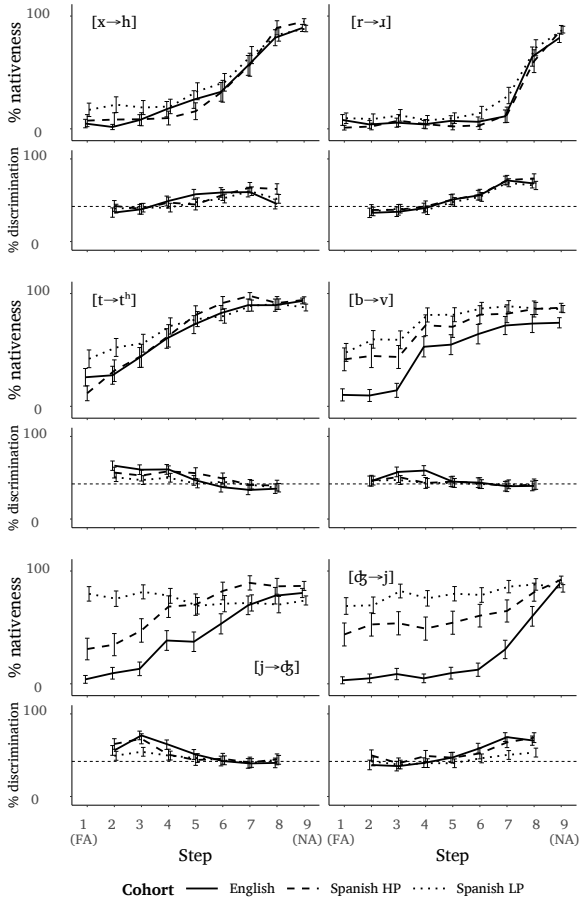


Figure 3: *Categorisation (top) and discrimination (bottom) responses for individual consonant continua.*

ing the nativeness of FA at the level of segments. When averaged across consonants, we observed clear differences between N and NN listeners (Fig. 2). In particular, N listeners were more sensitive to the presence of FA at the strongly-accented end of the continuum, whereas they converged with NN listeners for the more native-accented realisations. Individual segment results are more varied (Fig. 3), suggesting that perception of FA is strongly linked to the status of the foreign- and native-accented segments in the listeners' L1. When the relationship between the native segment and its foreign-accented realisation is not allophonic in the NN listeners' L1, NN listeners are as able to perceive segmental FA as N listeners. This is the case for the [x]→[h], [r]→[ɹ] and [t]→[tʰ] continua, in which the native English sound does not correspond to a possible realisation in the regional variety of the Spanish listener groups. For these three sounds, the native-accented realisation is a bad exemplar of the corresponding category for NN listeners' and therefore categorisation can be expected to be good [26]. On the other hand, when the native and accented segments are possible allophones in the NN L1 but phonemic in N listeners' L1, large differences between the two populations may be observed. Thus, Ns display excellent perception of /j/ and /ʤ/ as two separate categories, whereas NN listeners find it difficult to perceive two different categories as both sounds are good exemplars of /j/ in their L1. This behaviour supports L2 perception models that predict lack of perceptual sensitivity within an L1 category's perceptual space and heightened sensitivity between L1 categories [27, 26]. The continuum [b]→[v] deserves separate mention because of its special status in the NNs L1. As is the case with [h], [ɹ] and [tʰ], [v] is a bad exemplar of the [b] category in this cohort's variety of Spanish. However, orthographically "b" and "v" are homophones, both being pronounced as a weak plosive [b] or, more frequently, as a bilabial approximant. This may be the reason why in the [b]→[v] continuum NN listeners consider [b] to be an acceptable realisation of [v].

The second question concerned the effect of language proficiency on FA perception. Here, when N and NN listener judgements diverged, the difference was mainly due to the LP group, while HP listeners tended to pattern with N listeners. A case in point involves the continua [ʤ]→[j] and [j]→[ʤ], two segments which are good exemplars of the same phonemic category in Spanish. LP listeners judged these continua as near-native regardless of the position along the continuum. The problem of splitting one's own native acoustic space into several non-native categories has largely been studied for other segments and target languages [28, 29, 30, 31]. By contrast, the perception of these two continua by English listeners, for whom the segments at each end represent different phonemic categories, spanned the whole perceptual space: the initial steps were perceived as completely foreign-accented, the final steps were perceived as native, and the perceived differences between steps were generally more equally-sized. The responses of HP listeners are located midway between the LP group and N listeners. Our findings therefore support the idea that identification of segmental FA is substantially affected by listeners' proficiency in the target language, just as has been found for intelligibility of higher order units such as words [13] or sentences [15]. Even though their study was not focused on FA, [32] show that HP NN Japanese listeners resemble N English listeners more than LP NN Japanese listeners, or fall somewhere in between the two groups when asked to identify tokens in a synthetic /r/-/l/ continuum. Our results indicate that HP listeners are able to overcome their native phonological bias and can establish new phonemic boundaries for the English categories.

All cohorts had similar discrimination abilities. While categorisation is strongly shaped by the L1 phonological system [33, 34], discrimination is less dependent on linguistic factors, instead involving sensory acuity [33, 35]. The existence of a discrimination peak in the region of the steepest part of the categorisation continua is further evidence that new phonemic boundaries are being created in NN learners' L2 system.

## 5. Conclusions

A set of foreign- to native-accented consonant continua were categorised by N and NN listeners differing in language proficiency. Overall, N listeners were better at determining the presence of FA. At the level of individual segments, NN categorisation behaviour was dependent on the status of the foreign- and native-accented segments in their L1. High-proficiency NN listeners exhibited response patterns intermediate between those of N listeners and low-proficiency NN listeners, suggesting the emergence of new phonemic categories.

## 6. Acknowledgements

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