Bilingualism: Language and Cognition 19 (5), 2016, 914–920 © Cambridge University Press 2016 doi:10.1017/S136672891600002X

Lexically-guided perceptual learning in non-native listening*

POLINA DROZDOVA
Centre for Language Studies, Radboud University Nijmegen, The Netherlands
IMPRS for Language Sciences, Nijmegen, The Netherlands
ROELAND VAN HOUT
Centre for Language Studies, Radboud University Nijmegen, The Netherlands
ODETTE SCHARENBORG
Centre for Language Studies, Radboud University Nijmegen, The Netherlands
Donders Institute for Brain, Cognition and Behaviour, Radboud University Nijmegen, The Netherlands

(Received: February 6, 2015; final revision received: January 14, 2016; accepted: January 14, 2016; first published online 19 April 2016)

There is ample evidence that native and non-native listeners use lexical knowledge to retune their native phonetic categories following ambiguous pronunciations. The present study investigates whether a non-native ambiguous sound can retune non-native phonetic categories. After a brief exposure to an ambiguous British English [l/ɹ] sound, Dutch listeners demonstrated retuning. This retuning was, however, asymmetrical: the non-native listeners seemed to show (more) retuning of the /ɹ/ category than of the /l/ category, suggesting that non-native listeners can retune non-native phonetic categories. This asymmetry is argued to be related to the large phonetic variability of /r/ in both Dutch and English.

Keywords: lexically-guided perceptual learning, non-native listening, liquids

Introduction

The speech signal is variable: speakers pronounce sounds differently depending on, e.g., their gender, dialect, accent, and age. Listeners cope with this variation by quickly tuning into a speaker, even when pronunciations are ambiguous (Norris, McQueen & Cutler, 2003). There is ample evidence that native speakers use lexical and phonotactic knowledge to retune their phonetic categories in response to ambiguous pronunciations of sounds (see Samuel & Kraljic, 2009, for an overview), and apply this learning to novel items (McQueen, Cutler & Norris, 2006). This competence, termed lexically-guided perceptual learning (Norris et al., 2003), leads to temporary adjustments of phonetic category boundaries (Clarke-Davidson, Luce & Sawusch, 2008). We argue here that highly proficient non-native listeners are able to benefit from the same process and, as a result of a brief exposure to an ambiguous sound, can retune their second language (L2) phonetic category boundaries to include this ambiguous sound, and can apply this learning to new, unheard words.

Lexically-guided retuning has been demonstrated for native listeners using an exposure-test paradigm. In the seminal study by Norris et al. (2003), Dutch listeners were exposed to word items containing an ambiguous sound between /f/ and /s/. The authors demonstrated that listeners exposed to the ambiguous sound in /f/-final words (e.g., gira[f/s], where *giraffe* is an existing Dutch word and *giras* is not) learned to interpret the sound as /f/. The group exposed to the ambiguous sound in /s/-final words (e.g., mui[f/s], where *muis* (mouse) is an existing Dutch word) learned to interpret the same ambiguous sound as /s/. In a subsequent phonetic-categorization task, the listeners exposed to ambiguous /f/-final stimuli characterized stimuli on an [ɛf-ɛs] continuum more often as an [ɛf] than the other group, thus showing a retuning of their /f/ phoneme category.

For lexically-guided retuning to occur, the availability of lexical knowledge is critical. Since non-native listeners typically have an impoverished vocabulary in comparison to native listeners, their lexical-phonological knowledge is arguably less reliable (Lecumberri, Cooke & Cutler,

* This research is supported by a Vidi-grant from the Netherlands Organization for Scientific Research (NWO; grant number: 276-89-003) awarded to Odette Scharenborg. We thank Stephen Bodnar, Bart Penning de Vries, and Alastair Smith for their help in stimulus preparation, Juul Coumans for her help in co-running the experiment, Sven Mattys for the use of his testing facilities, and James McQueen for insightful discussions on the results.

Address for correspondence:
Polina Drozdova, Centre for Language Studies, Department of Linguistics, Radboud University Nijmegen, Erasmusplein 1, Postbus 9103, 6500 HD Nijmegen
p.drozdova@let.ru.nl
Supplementary material can be found online at http://dx.doi.org/10.1017/S136672891600002X

2010). Secondly, non-native listeners might not have a phonetic category for the non-native sound or it might differ from the one in the native sound system (Flege, 1995). It is therefore questionable whether non-native listeners would be able to retune (non-native) phonetic categories.

Results of a previous study on lexically-guided retuning by non-native listeners were not conclusive. Reinisch, Weber and Mitterer (2013) demonstrated that, on the basis of Dutch L2 input, highly proficient German learners of Dutch showed retuning for ambiguous /f-s/ sounds. These sounds are however highly similar in Dutch and German. As Reinisch et al. (2013) point out, their results could be explained by L2 input guiding L1 retuning rather than retuning L2 phoneme categories since non-native phonemes that are perceived as similar to native phonemes are assimilated to these native phoneme categories (Best & Tyler, 2007; Flege, 1995). In the present study, we investigate the question whether an ambiguous sound in a non-native language can retune L2 phonetic categories, using the British English sound contrast /ɹ/-/l/. The here-presented results extend those reported in Drozdova, van Hout and Scharenborg (2014, 2015).

While articulation of /l/ is fairly similar in Dutch and English (Collins & Mees, 2003), marked phonetic differences exist between British English and Dutch /r/. Realization of /r/ in Dutch depends on its position and on the speaker (e.g., Sebregts, 2015). In the onset position, uvular /ʀ/ trills or alveolar /r/ taps and trills are used while the variant closest to the British English one, the prevelar bunched approximant /ɹ/, only occurs in coda position (Mitterer, Scharenborg & McQueen, 2013; Scobbie, Sebregts & Stuart-Smith, 2009; Van de Velde & van Hout, 1999). British English, being non-rhotic, does not allow /ɹ/ in post-vocalic position (Collins & Mees, 2003). Dutch listeners thus would have to create a language-specific phonetic category for British English /ɹ/. If lexically-guided retuning is observed for Dutch listeners for the British English /ɹ/-/l/ sound contrast, this would then indicate that L2 phonetic boundaries can be retuned on the basis of ambiguous L2 input.

In the present study, Dutch non-native listeners of English were first exposed to one of two versions of a short story containing ambiguous [l/ɹ] sounds (Eisner & McQueen, 2006) and, subsequently, had to perform a phonetic-categorization task. We predict that if non-native listeners retune their L2 phonetic categories, non-native listeners in the /ɹ/-ambiguous group will show a greater proportion of /ɹ/ responses in the categorization task than listeners in the /l/-ambiguous group. To provide a baseline for the learning effect, a separate group of Dutch listeners only performed the categorization task (following, e.g., Zhang & Samuel, 2014). Moreover, since retuning has not yet been demonstrated for British English native listeners for the /l/-/ɹ/ contrast, a group of native British English listeners functioned as a control group.

Method

Participants

Eighty-nine native Dutch participants were recruited from the Radboud University Nijmegen subject pool of which 15 (3 males, M_{age}=23.1, SD=4.7) took part in the pretest of the stimuli, and 20 (6 males, M_{age}=21.1, SD=2.3) in the baseline experiment. The remaining 54 participants (11 males, M_{age} =21.6, SD=2.0) participated in the main experiment. All Dutch participants possessed a 'VWO' (i.e., pre-university education) diploma, indicating a B2 or higher level of English according to the European Framework of Reference. As a control group, 47 native British English participants (9 males, M_{age}=21.0, SD=2.2) were recruited from the participant pool of the University of York, UK. All participants were paid for their participation and none reported a history of hearing or learning disorders.

Materials

Nineteen English words containing one /ɹ/ sound and no /l/ sounds and 19 words containing one /l/ sound and no /ɹ/ sounds with word frequencies of at least 100 per million were selected from the CELEX database (Baayen, Piepenbrock & Gulikers, 1995). Since lexically-guided retuning is allophone-dependent (Mitterer et al., 2013), the /l/ or /ɹ/ target sound always occurred at the onset of the third or fourth syllable. The target words were embedded in a short story, which importantly, contained no other words with /l/ and /ɹ/. The story was recorded by a male native speaker of British English in three versions (normal; each /ɹ/ pronounced as /l/; each /l/ pronounced as /ɹ/). The target words were excised at the positive-going zero crossings. Two versions of each word (e.g., memory-memoly) were morphed with the STRAIGHT algorithm (Kawahara, Masuda-Katsuse & Cheveigne, 1999) to create an 11-step ambiguous word continuum where the interpretation of the ambiguous [l/ɹ] sound ranged from /l/ (step 0) to /ɹ/ (step 10). The most ambiguous variant of each individual word was chosen on the basis of a pretest with Dutch listeners. It was the step on the continuum that received approximately 50% /ɹ/ and 50% /l/ responses. This step was spliced back into the story to create two versions. In the /l/-ambiguous version, the /l/ sound in all words was replaced by the ambiguous [l/ɹ] sound while all /ɹ/ sounds were natural. In the /ɹ/-ambiguous version, all /ɹ/ sounds were replaced with the ambiguous [l/ɹ] sound while all /l/ sounds were natural.

In the phonetic-categorization task, two minimal pairs were used: *alive-arrive* and *collect-correct*. According to

CELEX (Baayen et al., 1995), *alive* is the most frequent word of the *alive-arrive* pair, while *correct* is the most frequent of the *collect-correct* pair, thus reducing bias towards an /l/ or /ɹ/ interpretation in the task. The words were recorded by the same male speaker, and morphed following the procedure described above. The test phase consisted of five steps from each minimal pair: the most ambiguous item chosen on the basis of the pretest, and the two steps directly preceding and following it. For the *alive-arrive* minimal pair these were steps 3–7, and for *collect-correct* these were steps 2–6.

Procedure

During the exposure phase, half of the non-native and native control group participants heard the /ɹ/-ambiguous version of the story while the other half listened to the /l/-ambiguous version. In the subsequent phonetic-categorization task, participants heard the 120 test stimuli divided over four blocks. They categorized the stimuli as containing an /l/ (left button on the button box) or /ɹ/ (right button on the button box). The whole procedure took approximately twenty minutes. Participants in the baseline condition only performed the phonetic-categorization task, which lasted approximately ten minutes.

Table 1. *Fixed-effect estimates of performance of native listeners in the phonetic categorization task, for the minimal pairs separately.*

Fixed effect	β	*SE*	$p <$
collect-correct			
Intercept	−3.977	0.451	.001
Exposure condition	1.363	0.602	.05
Step 2	1.663	0.339	.001
Step 3	4.486	0.368	.001
Step 4	5.253	0.378	.001
Step 5	8.265	0.491	.001
Exposure condition x Step 2	−0.272	0.430	*ns*
Exposure condition x Step 3	−1.016	0.460	.05
Exposure condition x Step 4	−1.148	0.475	.05
Exposure condition x Step 5	−0.693	0.767	*ns*
alive-arrive			
Intercept	−2.325	0.261	.001
Step 2	2.544	0.185	.001
Step 3	4.578	0.216	.001
Step 4	5.639	0.252	.001
Step 5	6.452	0.306	.001

Results

In the non-native condition, 26 Dutch participants listened to the /ɹ/-ambiguous version of the story and 28 to the /l/-ambiguous version. In the native English, control condition, 23 participants listened to the /ɹ/-ambiguous version and 24 to the /l/-ambiguous version. A generalized linear mixed-effect model analysis (Baayen, Davidson & Bates, 2008) was conducted on the responses in the phonetic-categorization task (/l/ coded as 0 or /ɹ/ coded as 1) using the logit link function. The analysis started from the model containing all predictors and all possible interactions between Exposure Condition (the critical variable), Continuum Step (the most /l/-like step was recoded as step 1, and the most /ɹ/-like step was recoded as step 5), and Minimal Pair. Additionally, by-Subject and by-Minimal-Pair random intercepts and slopes were added to the model. Subsequently, interactions and predictors that were not significant were removed one-by-one, and each subsequent model was compared with the previous one using the likelihood ratio test. Final model was selected by comparing AIC values on the basis of likelihood ratio tests and degrees of freedom (the number of factors). Factors and their interactions included in the initial, intermediate and final models and model comparison scores are presented in Supplementary materials A (supplementary materials).

Although, the analysis of the responses of the native listeners in the phonetic-categorization task did not reveal a general effect of Exposure Condition (β=- 0.67, *SE*=0.437, *p*=0.125), there was a significant interaction between Exposure Condition and Minimal Pair (β=1.296, *SE*=0.565, $p<.05$). Consequently, separate analyses were carried out for each minimal pair. Table 1 displays the estimates of the fixed effects and their interactions in the best-fitting model for the native listeners for the *collect-correct* (upper part) and the *alive-arrive* (lower part) minimal pair.

Figure 1 shows the proportion of /ɹ/ responses for the 5 steps of the /l/-/ɹ/ test continuum for the /l/-ambiguous group (solid line with squares) and the /ɹ/-ambiguous group (dashed line with triangles) for the results for *alive-arrive* (left panel) and *collect-correct* (right panel). The difference between the curves of the two exposure groups, indicating the lexically-guided retuning effect, was significant only for *collect-correct* (see Table 1, Exposure Condition; Exposure Condition was not significant for *alive-arrive* in the final, best-fitting model, Exposure Condition in the penultimate model: β=- 0.668, *SE*=0.436, *p*=0.125). Native participants, therefore, demonstrated lexically-guided retuning for the /l/-/ɹ/ continuum, albeit only for the *collect-correct* pair.

Table 2 displays the estimates of the fixed effects and their interactions in the best-fitting model for the non-native listeners for both minimal pairs together. Similar to Figure 1, Figure 2 shows the proportion of /ɹ/ responses of the non-native listeners for the 5 steps of the

Table 2. *Fixed-effect estimates of performance of non-native listeners in the phonetic categorization task.*

Fixed effect	β	SE	$p <$
Intercept	−2.428	0.287	.001
Exposure condition	1.188	0.359	.001
Step 2	1.816	0.209	.001
Step 3	4.092	0.229	.001
Step 4	5.493	0.265	.001
Step 5	5.770	0.297	.001
Minimal pair	−1.003	0.324	.01
Exposure condition x Step 2	−0.741	0.240	.01
Exposure condition x Step 3	−1.145	0.260	.001
Exposure condition x Step 4	−1.845	0.290	.001
Exposure condition x Step 5	−1.606	0.352	.001
Step 2 x Minimal pair	−0.101	0.238	*ns*
Step 3 x Minimal pair	0.336	0.256	*ns*
Step 4 x Minimal pair	0.339	0.285	*ns*
Step 5 x Minimal pair	2.180	0.367	.001

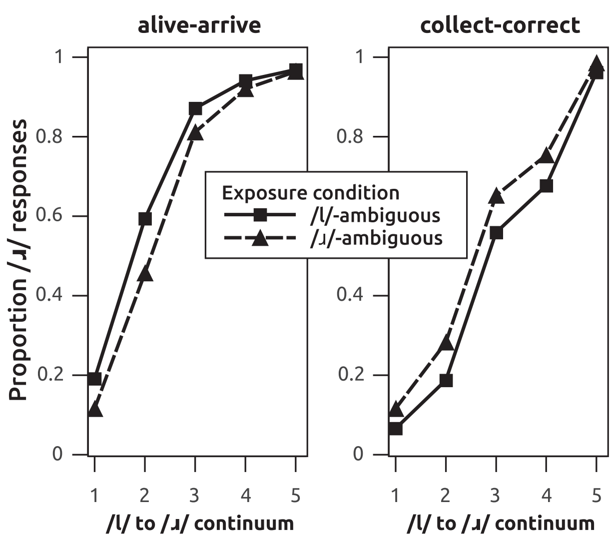

Figure 1. Proportion of /ɹ/ responses for the alive-arrive (left) and collect-correct (right) test continua for the native listeners. Responses of the listeners in the /ɹ/-ambiguous group are plotted with the dashed line with triangles; responses of the listeners in the /l/-ambiguous group are plotted with the solid line with squares.

/l/-/ɹ/ continuum for the two minimal pairs separately. Crucially, the /ɹ/-ambiguous group gave significantly more /ɹ/ responses than the /l/-ambiguous group (Table 2, Exposure Condition), showing lexically-guided retuning.

To investigate whether retuning occurred for the non-native listeners for the crucial /ɹ/ category, the responses of both exposure groups were compared to the responses of the 20 non-native participants in the baseline condition (no exposure to the ambiguous sound; see dotted line with bullets in Figure 2). In the statistical analysis, baseline was added as a third level to the factor Exposure Condition as reference category. No significant difference was found between the baseline condition and the /l/-ambiguous group (see Table 3: Exposure Condition-/l/-amb). Crucially, however, the listeners in the /ɹ/-ambiguous group gave significantly more /ɹ/ responses in the phonetic-categorization task than the baseline group (Table 3: Exposure Condition-/ɹ/-amb). Retuning was thus observed for the group exposed to the /ɹ/-ambiguous version but not the /l/-ambiguous version of the story[1].

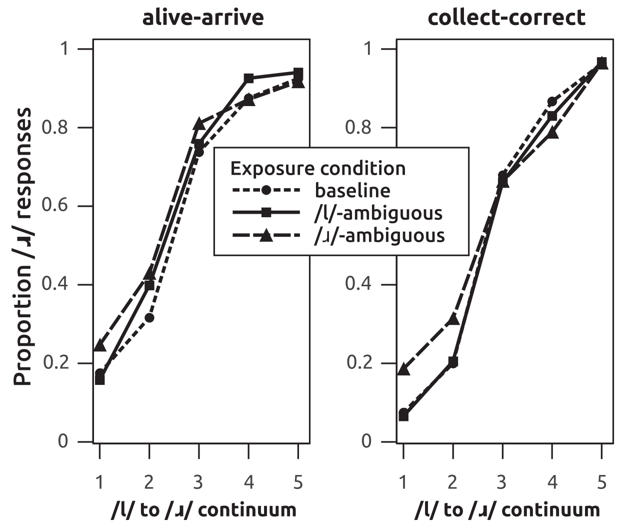

Figure 2. Proportion of /ɹ/ responses for the alive-arrive (left) and collect-correct (right) test continua for the non-native listeners. Responses of the listeners in the /ɹ/-ambiguous group are plotted with the dashed line with triangles; responses of the listeners in the /l/-ambiguous group are plotted with the solid line with squares, responses of the listeners in the baseline group are plotted with the dotted line with bullets.

Discussion and conclusions

According to the PAM-L2 model (Best & Tyler, 2007), L2 phonemes that are perceived as phonologically similar but phonetically deviant from the corresponding L1 phonemes are dissimilated from their L1 equivalent at the phonetic level, and form a separate language-specific phonetic category. This hypothesis is corroborated by the finding that French listeners of English tend to

[1] Additional analyses (see Supplementary materials A, Tables S6-8) investigating a possible difference in the magnitude of perceptual learning between the English and Dutch listeners showed no significant interaction between Language Group and Exposure Condition. Only for the *alive-arrive* pair the interaction between Exposure Condition and Language Group was significant (β=-1.535, SD=0.667, p<.05), which is in agreement with the earlier observed difference between the language groups regarding *alive/arrive*.

Table 3. *Fixed-effect estimates of performance of non-native listeners in the phonetic categorization task including the baseline condition.*

Fixed effect	β	SE	$p <$
Intercept	−2.112	0.315	.001
Exposure condition- /l/-amb	−0.285	0.390	*ns*
Exposure condition - /ɹ/-amb	0.913	0.379	.05
Step 2	1.201	0.223	.001
Step 3	3.607	0.238	.001
Step 4	4.852	0.272	.001
Step 5	5.215	0.310	.001
Minimal pair	−1.113	0.290	.001
Exposure condition-/l/-amb x Step 2	0.568	0.278	.05
Exposure condition-/ɹ/-amb x Step 2	−0.176	0.255	*ns*
Exposure condition-/l/-amb x Step 3	0.404	0.298	*ns*
Exposure condition-/ɹ/-amb x Step 3	−0.744	0.274	.01
Exposure condition-/l/-amb x Step 4	0.493	0.338	*ns*
Exposure condition-/ɹ/-amb x Step 4	−1.350	0.306	.001
Exposure condition-/l/-amb x Step 5	0.517	0.398	*ns*
Exposure condition-/ɹ/-amb x Step 5	−1.092	0.370	.01
Step 2 x Minimal pair	0.032	0.208	*ns*
Step 3 x Minimal pair	0.555	0.224	.05
Step 4 x Minimal pair	0.671	0.249	.01
Step 5 x Minimal pair	2.297	0.317	.001

perceive British English /ɹ/ as /w/-like, despite French and English both having a phonological category for /r/ (Halle, Best & Levitt, 1999). French listeners in that study dissimilated English /ɹ/ from French /r/ at the phonetic level because English and French /r/ differ phonetically. In our experiment, English /l/ is most likely assimilated with Dutch /l/, as the phonetic realization of /l/ in English and Dutch is highly similar. On the other hand, marked differences exist in the phonetic realizations of British English and Dutch /r/, similar to the French case (Halle et al., 1999). The Dutch /r/ closest to British English /ɹ/ only occurs in coda position, where the British English /ɹ/ does not appear. Following PAM-L2, British English /ɹ/ would require a language-specific phonetic category for the Dutch listeners.

The proportion of /ɹ/ responses of the non-native listeners exposed to the /ɹ/-ambiguous version of the story was significantly larger than that of the non-native listeners in the /l/-ambiguous and the baseline groups, demonstrating retuning in non-native listeners in the /ɹ/-ambiguous condition. Three explanations seem possible for this finding: the size of the native /l/-category shrank to exclude ambiguous pronunciations, the size of the non-native /ɹ/-category widened to include ambiguous pronunciations, or a combination of both happened. Solely a retuning of the /l/-category seems to be the least plausible, as the /ɹ/-ambiguous participants were exposed to natural /l/-tokens, and were unaware that /l/-/ɹ/ was the target contrast in the study. Moreover, if exposure to an ambiguous sound in an /ɹ/-context would lead to shrinking of the /l/-category, one would also expect a reduction in the size of the /ɹ/-category for the listeners in the /l/-ambiguous group. This was not found. So, even if exposure to the ambiguous sound caused a reduction in the size of the /l/-category, the size of the /ɹ/-category needs to increase to account for our data.

In contrast to what is typically found in native listeners (e.g., compare Figures 1 and 2), the non-native retuning seems to be concentrated mostly on the /l/-side of the continuum. Potentially, native listeners have a better developed /ɹ/-category than non-native listeners, helping them to flexibly adjust category boundaries when faced with ambiguous pronunciations. The arguably less well-developed /ɹ/-category of the non-natives might result in a retuning that is more bound to specific rather than a range of ambiguous steps. Taken together, we conclude that the observed retuning effect seems to suggest that L2 listeners can, in addition to their L1, also retune their L2 phonetic categories, albeit perhaps in a ‘narrower’ sense than native listeners.

The responses in the phonetic-categorization task of the non-native /l/-ambiguous group did not differ significantly from those of the non-native baseline group. This asymmetry in lexically-guided retuning has previously been demonstrated for the /s/-/f/ contrast (Eisner & McQueen, 2006; Norris et al., 2003; Zhang & Samuel, 2014), where the /s/-ambiguous group experienced a stronger retuning than the /f/-ambiguous group. Zhang and Samuel (2014) argued that the frication cue of /f/ is weaker than that of /s/ and therefore more susceptible to variation, which in turn would block retuning. We want to add a complimentary interpretation: the acoustic variation for /ɹ/ both in British English and Dutch is high both in allophonic variation and between speakers, higher than that of /l/. Like /ɹ/, /s/ has large inter-speaker variation (Dart, 1991, 1998), more so than /f/ (Gordon, Barthmaier & Sands, 2002), suggesting that the acoustics of /s/ are inherently more variable than those of /f/. Taken together, potentially, listeners more easily retune phoneme categories of sounds which are acoustically variable, after exposure to artificially-induced variation, as they are used to hearing this variation and adapting these phoneme categories. This explanation is in agreement with studies on talker variability (Bradlow & Bent, 2008, Clopper & Pisoni, 2004) which show that highly variable training stimuli (e.g., exposure to different voices) promote perceptual learning. Whether indeed sounds with high(er) inherent acoustic variability are more prone to retuning than more stable sounds is an interesting question for future research.

Surprisingly, lexically-guided retuning for the native listeners only occurred for the *collect-correct* pair. Potentially, the steps used for the *alive-arrive* pair were not well positioned for native listeners as the ambiguous steps were chosen on the basis of a pre-test with non-native listeners. Post-hoc acoustic analyses indeed revealed that the first step of the *alive-arrive* continuum was more /ɹ/-like than the first step of the *collect-correct* continuum (see Drozdova et al., 2014, for more discussion). This slight /ɹ/-bias could possibly reduce the perceptual learning effect.

To summarize, our results suggest that non-native listeners are able to retune their non-native phonetic boundaries. This suggests that the mechanisms underlying lexically-guided perceptual learning in non-native listening correspond to those observed in native listening (Norris et al., 2003; Samuel & Kraljic, 2009), although perhaps in a somewhat 'narrower' sense, and that non-native listeners enjoy a similar remarkable flexibility at the prelexical/phonetic level which has previously been associated with native listening (Cutler, 2012).

Supplementary material

For supplementary material accompanying this paper, visit http://dx.doi.org/10.1017/S136672891600002X

References

Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language, 59,* pp. 390–412. http://dx.doi.org/10.1016/j.jml.2007.12.005

Baayen, R., Piepenbrock, R., & Gulikers, L. (1995). The CELEX lexical database (release 2), PA: Linguistic Data Consortium, University of Pennsylvania.

Best, C. T., & Tyler, M. D. (2007). Nonnative and second-language speech perception: Commonalities and complementarities. In O.S. Bohn & M. J. Munro (Eds.), *Language experience in second language speech learning: In honor of James Emil Flege*. Amsterdam, The Netherlands: John Benjamins.

Bradlow, A., & Bent, T. (2008). Perceptual adaptation to non-native speech. *Cognition, 106(2),* pp. 707–729. http://dx.doi.org/10.1016/j.cognition.2007.04.005

Clarke-Davidson, C. M., Luce, P. A., & Sawusch, J. R. (2008). Does perceptual learning in speech reflect changes in phonetic category representation or decision bias? *Perception & Psychophysics, 70,* pp. 707–729. http://dx.doi.org/ 10.3758/PP.70.4.604

Clopper, C., & Pisoni, D. (2004). Effects of talker variability on perceptual learning of dialects. *Language and Speech, 47(3),* pp. 207–238. http://dx.doi.org/10.3758/PP.70.4.604

Collins, B., & Mees, I. M. (2003). *The phonetics of English and Dutch*. Leiden, The Netherlands: Brill

Cutler, A. (2012). Native listening: The flexibility dimension. *Dutch Journal of Applied Linguistics, 1,* pp. 169–187. http://dx.doi.org/10.1075/dujal.1.2.02cut

Dart, S. (1991). Articulatory and acoustic properties of apical and laminal articulations. Ph.D. dissertation, University of California, Los Angeles [*UCLA Working Papers in Phonetics*, 79].

Dart, S. (1998). Comparing French and English coronal consonant articulation. *Journal of Phonetics, 26,* pp. 71–94. http://dx.doi.org/10.1006/jpho.1997.0060

Drozdova, P., van Hout, R., & Scharenborg, O. (2015). The effect of non-nativeness and background noise on lexical retuning. Proceedings of *the International Congress of Phonetic Sciences*, Glasgow, UK.

Drozdova, P., van Hout, R., & Scharenborg, O. (2014). Phoneme category retuning in a non-native language. *Proceedings of Interspeech 2014, Singapore*, pp. 553–557.

Eisner, F., & McQueen, J. M. (2006). Perceptual learning in speech: Stability over time. *Journal of the Acoustical Society of America, 119,* pp.1950–1953. http://dx.doi.org/10.1121/1.2178721

Flege, J. E. (1995). Second language speech learning: Theory, findings, and problems. In W. Strange (Ed.), *Speech perception and linguistic experience: Issues in cross-language research*. Timonium, MD: York Press, pp.233–277.

Gordon, M., Barthmaier, P., & Sands, K. (2002). A cross-linguistic acoustic study of voiceless fricatives. *Journal of the International Phonetic Association, 32,* pp.141-174.

Halle, P. A., Best, C. T., & Levitt, A. (1999). Phonetic vs. phonological influences on French listeners' perception of American English approximants. *Journal of Phonetics, 27,* pp. 281–306.

Kawahara, H., Masuda-Katsuse, I., & Cheveigne, A (1999). Restructuring speech representations using a pitch-adaptive time-frequency smoothing and an instantaneous-frequency-based F0 extraction: possible role of a repetitive structure in sounds, *Speech Communication, 27,* pp.187-207. http://dx.doi.org/10.1016/S0167-6393(98)00085-5

Lecumberri, M. L. G., Cooke, M., & Cutler, A. (2010). Non-native speech perception in adverse conditions: A review. *Speech Communication, 52,* pp.864–886. http://dx.doi.org/10.1016/j.specom.2010.08.014

McQueen, J. M., Cutler, A., & Norris, D. (2006). Phonological abstraction in the mental lexicon. *Cognitive Science, 30,* pp.1113–1126. http://dx.doi.org/10.1207/s15516709cog0000_79

Mitterer, H., Scharenborg, O., & McQueen, J. M. (2013). Phonological abstraction without phonemes in speech perception. *Cognition, 129,* pp. 356–361. http://dx.doi.org/10.1016/j.cognition.2013.07.011

Norris, D., McQueen, J. M., & Cutler, A. (2003). Perceptual learning in speech. *Cognitive Psychology, 47,* pp. 204–238. http://dx.doi.org/10.1016/S0010-0285(03)00006-9

Reinisch, E., Weber, A., & Mitterer, H. (2013). Listeners retune phoneme categories across languages. *Journal of Experimental Psychology: Human Perception and Performance, 39,* pp. 75–86. http://dx.doi.org/10.1037/a0027979

Samuel, A. G., & Kraljic, T. (2009). Perceptual learning for speech. *Attention, Perception, & Psychophysics, 71,* pp. 1207–1218. http://dx.doi.org/10.3758/APP.71.6.1207

Scobbie, J. M., Sebregts, K., & Stuart-Smith, J. (2009). Dutch rhotic allophony, coda weakening, and the phonetics-phonology Interface. QMU Speech Science Research Centre, Working Papers, WP-18.

Sebregts, K. (2015). *The sociophonetics and phonology of Dutch r*. PhD University Utrecht, LOT Publications 379.

Van de Velde, H., & van Hout, R. (1999). *Linguistics in the Netherlands 1999*. van Bezooijen, R. & Kager, R. (eds.). Amsterdam Philadelphia: Benjamins, pp. 177–188. https://pure.uvt.nl/portal/en/publications/the-pronunciation-of-r-in-standard-dutch(84fc3cbc-a4aa-4e55-a09c-82db073345b8).html

Zhang, X., & Samuel, A. G. (2014). Perceptual learning of speech under optimal and adverse conditions. *Journal of Experimental Psychology: Human Perception & Performance, 40,* pp. 200–217. http://dx.doi.org/10.1037/a0033182