Speech Prosody 2022
23-26 May 2022, Lisbon, Portugal

The effects of prosodic prominence on the acquisition of L2 phonological features

Fabián Santiago[1], *Paolo Mairano*[2] & *Bianca de Paolis*[1,3]

[1]Université Paris 8 & CNRS (Structures Formelles du Langage)
[2]Université de Lille & CNRS (Savoirs, Textes, Langage)
[3]Università di Torino & LFSAG (Laboratorio di fonetica sperimentale Arturo Genre)
{fabian.santiago.ling; paolo.mairano; bianca.depaolis}@gmail.com

Abstract

Mainstream L2 phonology models do not include predictions concerning how the prosodic structure interacts with the acquisition of segments. However, many studies have shown that the realization of pitch accents or melodic contours associated to prosodic boundaries results in the hyper-articulation of segments in correspondence of such prosodic boundaries. Our goal is to provide empirical evidence for the positive effects of prosodic prominence on the acquisition of challenging L2 French sounds

The prosodic-phonetic interface has been largely underestimated in second language acquisition. Few studies have investigated whether prosodic prominence may serve as an optimal context for learners to extract information on the acoustic properties of new sounds, which may then be reflected in more accurate productions. In this paper, we report the acoustic patterns of L2 French vowels produced in two different prosodic conditions: (1) in word internal position (unaccented), (2) in initial and final boundaries of Accentual Phrases and Intonation Phrases. We analyzed oral productions by 40 participants: 10 French native speakers and 30 L2 French learners with L1 Spanish, L1 English and L1 Italian (10 each). We extracted acoustic parameters for ~15k vowels and calculated the degree of acoustic overlap via Pillai scores for the following triplets: /i/~/y/~/u/, /e/~/ø/~/o/. Our results show that prosodic prominence results in a smaller acoustic overlap of some L2 French vowel contrasts.

Index Terms: L2 prosodic strengthening, L2 French vowels, Pillai Scores

1. Introduction

The acquisition of L2 suprasegmentals and L2 segmentals have been largely studied as independent dimensions. Mainstream L2 phonology models such as *Speech Learning Model* [1], *Perceptual Assimilation Model* [2] or the *L2 Intonation Learning Theory* [3] do not make any predictions concerning prosodic effects on the acquisition of segmentals or vice versa. However, research in L1 phonology has shown that the articulation of sounds is finetuned by the prosodic structure. Literature examining the phonetics-prosody interface in English [4], Korean [5, 6] or French [7, 8] has demonstrated that the realization of prosodic boundaries modulates the phonetic realization of adjacent segments. These findings show that individual segments tend to be hyper-articulated (or strengthened) at domain-initial/final positions of Intonation/Phonological Phrases or at the edges of prosodic words. More particularly, vocalic segments produced at the edges of prosodic constituents tend to be lengthened and to occupy more peripheral positions in the vowel space.

Some studies have also looked into the effects of the prosodic hierarchy on the acoustic/articulatory characteristics of segments. In French [7], English [4] or German [8], vowels tend to be considerably reinforced reflecting the level of the prosodic hierarchy in which they occur: the higher the level of the prosodic constituents, the stronger the hyper-articulation of vowels. This raises the question whether L2 learners are able to reproduce such vowel hyper-articulation as a function of the prosodic structure of the target language. Although the phonetics-prosody interface has been widely studied in L1 phonology, this domain has not been sufficiently investigated in L2 speech leaving many crucial questions: How do prosody and segments interplay in an L2? What is the connection between the phonetics-prosody interface and learners' L1? To what extent may prosody serve as frame promoting the acquisition of new phonological features?

These questions have been grazed by a few studies adopting different approaches. In the domain of L2 teaching practice, some scholars propose that prosodic prominence combined with body movements supports the acquisition of new L2 phonological features. In the view of scholars and practitioners endorsing the verbo-tonal method [9], prosody is one of the first dimensions that should be taught in L2 classes, as it is thought to promote accurate perception and production of L2 segments. This teaching practice assumes that the phonetic salience of vowels is enhanced under prosodic prominence, so L2 learners will better perceive the roundness of French vowels [y] and [ø] in accented syllables or at initial/final domains of intonation phrases [9, 10]. Furthermore, the accurate perception and production of the [+rounded] feature is thought to be promoted by body gestures accompanying and illustrating the prosodic patterns.

Recent studies supporting the embodied cognition paradigm also consider that gestures and prosodic prominence facilitate the acquisition of novel contrasts [11, 12, 13]. Although the idea that prosodic strengthening could serve as a natural frame promoting the acquisition of L2 sounds seems reasonable, results of empirical studies examining this hypothesis are not always consistent. [10] evaluated the impact of both gestures mimicking prosody and prosodic prominence on the acquisition on L2 French vowels by English learners and did not find evidence for positive effects of prosody on L2 segmental acquisition. However, [11, 12, 13] report that both gestures and prosodic prominence have positive effects in the acquisition of novel L2 French vowel features by Catalan learners. Such contradictory results may be due to differences in participants' characteristics and experimental designs (tasks

10.21437/SpeechProsody.2022-77

for measuring vowel accuracy, number of training sessions, learners' L1 among others).

Some studies have addressed the prosodic-phonetic interface in L2 in terms of L1 transfer: [14] report that VOT values for the [+voiced] contrast in L2 English plosives by Korean learners reflect patterns of the prosody-phonetics relationship of learners' L1. In other words, the prosodic strengthening of Korean is mapped to VOT values in L2 English. In line with this finding, we found in a previous study ([15]) that L1 Spanish and L1 English learners of L2 French produce peripheral vowels [i], [a] [u] by reinforcing the [+open] and [+back] features along three different prosodic conditions: unaccented, at the initial/final domains of APs and at the initial/final domains of IPs. We claimed that the prosody-phonetics interface in an L2 is reflected in the spectral properties of these vowels, but this effect is not necessarily a transfer from the L1: L2 French vowels are similarly hyper-articulated independently of the level of the prosodic constituent in which they occur. We suggested that L2 prosodic strengthening may be modulated by universals at intermediate proficiency levels and not necessarily a result of a negative/positive L1 transfer.

All in all, the literature seems to suggest that prosody may interact with phonetics when acquiring new L2 sounds. In this study, we add a contribution aimed at improving our understanding of this issue by examining the role of prosodic prominence on the acquisition of challenging L2 French vowels: [y], [ø], [œ]. We analyze L2 speech data by learners with different L1 backgrounds: Spanish, English and Italian. Learners of these L1s experience difficulty in producing French front rounded vowels since lip rounding is not a distinctive feature in any of the three L1s. As a consequence, vowel [y] is often produced as [u] by both Spanish and Italian learners, and as [i] or [ʉ] by English learners. Vowels [ø] and [œ] tend instead to be confused with either [e] / [ɛ] or [o] / [ɔ].

Our goal is to investigate whether prosodic prominence (presence vs absence of prosodic accents) favors accurate production of the following vowel triplets: [i]-[y]-[u]; [e]-[ø]-[o] and [ɛ]-[œ]-[ɔ]. Note that in our approach we conflate prosodic prominence and prosodic boundaries despite the fact that this may not be the case in our learners' L1, because the target language (French) does not distinguish between these two. Our hypothesis is that the production of prosodic prominence marking the initial/final edges of an AP in L2 French results in the hyper-articulation of vowels. This promotes a better realization of the [+rounded] feature distinguishing [i]-[y], [e]-[ø] and [ɛ]-[œ] and of the [+back] feature distinguishing [y]-[u]; [ø]-[o] and [œ]-[ɔ].

2. Methods

2.1. Corpora

The data analysed in this study come from different L2 learner corpora developed for the study of L2 supra-/segmentals. We extracted 15,127 vowels produced by 10 French native speakers (control group) and 30 adult learners of L2 French coming from different L1 backgrounds: Mexican Spanish, RP English and Northern Italian (10 each). Vowels were produced in the context of read-aloud tasks in the following corpora: COREIL [16], Aix-Ox [17] and ProSeg [18]. We selected 8 short passages from the read-aloud tasks of each corpus providing comparable material in terms of number of words and sentence length. L2 French learners were attending French classes at intermediate or advanced proficiency levels, as illustrated in Table 1.

Table 1: *Description of the data.*

Corpus	N. of Part.	Group	L1	L2 Fr. level	Tokens
Coreil	10	FL1	French	native	3.735
Coreil	10	FL2-S	Spanish	Intermediate (B1/B2)	3.373
Aix-Ox	10	FL2-E	English	Intermediate (B1/B2)	3.859
ProSeg	10	FL2-I	Italian	Interm./Ad. (B2/C1)	4.160

2.2. Metrics of prosodic prominence

Prosodic prominence was first predicted by a syntax-to-prosody mapping following [19]. The goal was to detect all APs in the syntactic group consisting of any lexical word with the clitics on its non-recursive side (i.e., left, in French). Vowels at the initial and final boundaries of APs were considered as potential locations of prosodic prominence: pitch accents. Second, we verified the presence of prosodic prominence with a semi-automatic annotation using both Polytonia [20] and impressionistic evaluation by the first and third authors. Polytonia notation provides symbols indicating that vowels were produced either with rising melodic contours (Lr, Hr) or with high pitch values (M or H) for French. These labels are integrated in the Prosogram system [21], which automatically identifies any melodic movement perceptible with a glissando of 0,32/T2. All vowels marked as initial/final locations of AP and labeled with a rising/high melodic movement were considered as accented. Vowels in prenuclear position produced within a low pitch range and not labeled by Polytonia were considered as unaccented. For instance, potential locations of prosodic prominence for the utterance *Ma soeur a une peur bleue de l'obscurité* (*Ma sister is very afraid of darkness*) are illustrated in (1) and their prosodic realizations in (2). Figure 1 illustrates this utterance as produced by a French native speaker. According to Polytonia, it contains three APs delimited by final prosodic prominence coded with H and M labels:

1. [Ma soeur]$_{AP}$ [a une peur]$_{AP}$ [bleue]$_{AP}$ [de l'obscurité]$_{AP}$
2. (Ma soeur)$_{AP}$ (a une peur bleue)$_{AP}$ (de l'obscurité)$_{AP}$

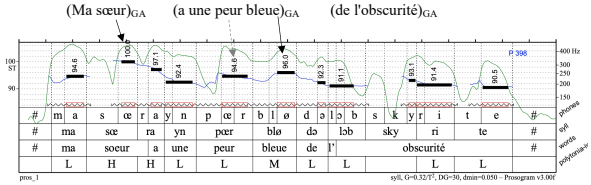

Figure 1: *Prosodic annotation via the Polytonia system*

Final accented vowels of APs in French in utterance-final position were also considered as locations of right boundaries of higher prosodic constituents as IPs [19]. We decided to not make a second category of prosodic prominence (in contrast to what was done by [15], who distinguished three prosodic levels: word-internal > AP > IP) and not to distinguish the type of melodic contour in the analysis because our data were not sufficient to allow for such differentiations: the different vowels

would not appear a sufficient number of times in each condition (IP with rise, IP with fall, AP with rise, etc.). Therefore, we merged all accented vowels in the same category as prominent, even if we acknowledge that vowels in final positions of nuclear AP may be more strengthened since they are, at the same time, locations of final IP boundaries. In short, we defined *accented* vowels all those segments associated to (pre-)nuclear initial/final pitch accents marking the edges of APs/IPs, whereas *unaccented* vowels did not display any prosodic cue of prominence.

2.3. Acoustic metrics for assessing L2 vowel accuracy

F1, F2 and F3 values were extracted at the mid-point of every target vowel /i/, /y/, /u/, /e/, /ø/, /o/, /ɛ/, /œ/, /ɔ/ via a custom *Praat* script. Vowels marked as hesitations or errors in the annotation were discarded from the analysis. In the attempt to exclude values affected by formant detection errors from the analysis, we discarded vowels whose F1, F2 or F3 was >2.5 *SD* from the mean (computed for each vowel for each participant), leaving 15,127 tokens for analysis (7,031 accented and 8,096 unaccented). Formant values were then normalized following Lobanov's procedure in order to minimize the effect of physiological/anatomical vocal tract differences among participants. Since the contrast between /ø/ vs /œ/, /e/ vs /ɛ/ and /o/ vs /ɔ/ is not maintained by all native French speakers and is usually not taught to L2 French learners, we considered realisations of /ø/ and /œ/, /e/ and /ɛ/ as well as /o/ and /ɔ/ belonging to the same category: respectively /ø/, /e/ and /o/.

In order to quantify the overlap of realizations for target vowel pairs, we computed Pillai scores. This score has been used in the literature to evaluate the degree of vowel mergers and splits [22] and to assess L2 pronunciation [23, 24]. Pillai scores range from 0 (complete overlap of categories) to 1 (complete separation of categories). For this study, we extracted Pillai scores for realisations of each participant in accented vs unaccented position of each target contrast fro*m MANOVAS* predicting F1, F2, F3 with vowel category as independent variable. Note that, although duration differences across French vowels are documented in the literature, we did not include this variable because duration is of course most strongly affected by prosodic condition, and as such it was considered when selecting accented vowels.

We expect hyper-articulation in accented position to result in higher Pillai scores, indicating more articulatory precision and therefore more category separation. Figure 2 and Table 2 illustrate these assumptions for two sample speakers: a French native speaker (FL1_S11) and an Italian learner of L2 French (FL2-I_S02).

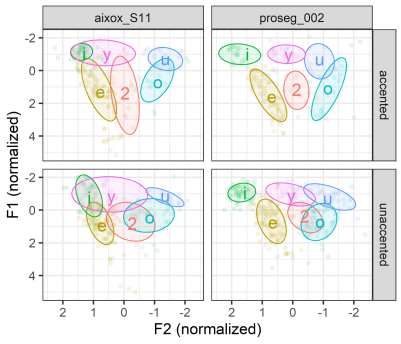

Figure 2: *F1xF2 chart two sample speakers. Ellipses encompass 66.67% of the data.*

Table 2: *Pillai scores for two sample speakers*

Speaker	Accent	/i/ ~ /y/	/y/ ~ /u/	/e/ ~ /ø/	/ø/ ~ /o/
FL1	Acc.	0.50	0.75	0.27	0.68
(S11)	Unacc.	0.40	0.64	0.41	0.18
FL2-I	Acc.	0.52	0.49	0.34	0.72
(S02)	Unacc.	0.63	0.53	0.39	0.16

3. Results

Average Pillai scores by group and by prosodic condition are reported in Table 3 and Figure 3, while Figure 4 illustrates the variability of Pillai scores by speaker. The Figures show that, globally, prosodic prominence seems to have an effect on the spectral quality of vowels across all groups (cf. H1: prosodic prominence has positive effects on the pronunciation accuracy of [±rounded] L2 French vowels). More specifically, the acoustic overlap of vowels produced in the accented condition is lower compared to their unaccented counterparts. In the case of the FL1 control group, our results are in line with [7, 8] who have previously demonstrated that prosodic prominence results in hyper-articulated/more canonical vowels. In the case of learners, accented vowels display more articulation accuracy than unaccented ones.

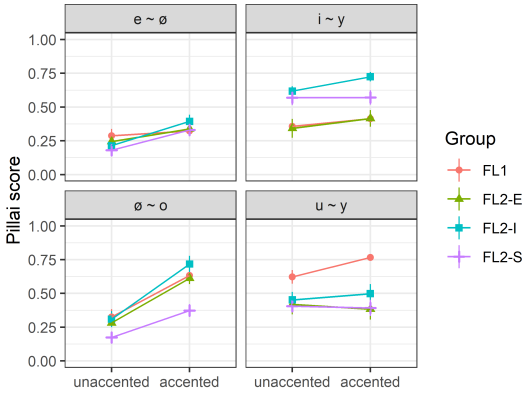

Figure 3: *Pillai scores by target pair, prosodic condition and group, averaged over participants.*

The results were analysed statistically with separate *ANOVAS* for each target pair with Pillai score as the dependent variable, and Group, Prosodic condition and their interaction as independent variables. For the /e/~/ø/ pair, the prosodic condition had a significant effect ($p < .001$) on vowel overlap, but not the L1 or their interaction, suggesting that category separation is greater in accented position for all groups. For the /ø/~/o/ pair, the prosodic condition and the L1 had a significant effect (all p values < .001) on vowel overlap, but not their interaction; fdr-corrected pairwise t-tests revealed that vowels produced by the FL2-S overlapped more than for other speakers (all p values < .05). For the /i/~/y/ pair, the effect of prosodic condition tended to significance ($p = .06$), and that of L1 was significant ($p < .001$); fdr-corrected pairwise t-tests revealed that the FL2-I and FL2-S groups differed from the FL1 and FL2-E (all p values < .01). Note that the relative low Pillai values for /i/~/y/ and /e/~/ø/ in the control group (FL1) are due to the fact that members of these pairs share similar articulatory properties (frontness and openness) which are of course reflected acoustically.

For the /u/~/y/ pair, we only observed a significant effect of L1, with the FL1 group showing a better category separation than all other groups (all p values < .001).

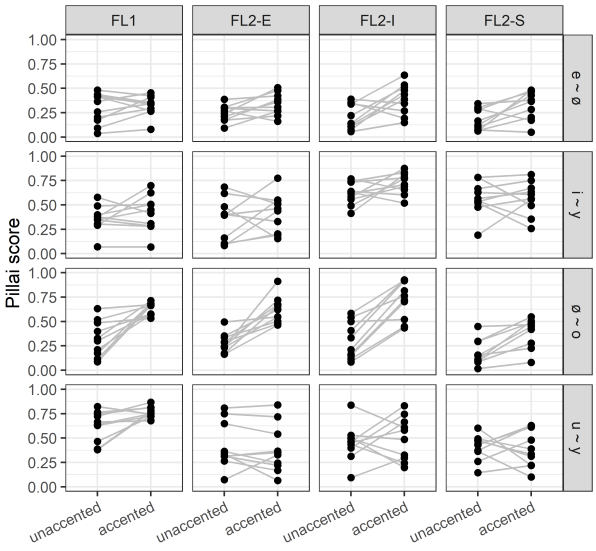

Figure 4. *Pillai scores (indicating category separation) for all speakers by target pair, prosodic condition and group.*

4. Discussion & Conclusions

We have presented data illustrating the effects of prosodic prominence on the acquisition of L2 features. The data showed that adult learners from different L1 backgrounds reinforce some L2 French vowels carrying prosodic prominence, but only partially confirmed our hypothesis. On the one hand, Pillai scores for accented vowels revealed that both native and L2 learners tend to hyperarticulate the triplets /i/-/y/-/u/ and /e/-/ø/-/o/ in accented positions. As revealed by statistical analyses, these vowel contrasts tend to overlap less in accented condition. These results expand findings by [15] suggesting that prosodic strengthening applies not only to L2 vowels that are similar to the L1 system ([i], [u] and [a]), but also to L2 vowels that do not exist in learners' native language. Note that, aside from L1 Spanish [25], the presence of pitch accents triggers vowel hyper-articulation in L1 English [4, 5] and L1 Italian [26]. In our view, the spectral changes modulated by the prosodic structure in L2 French could be seen as a positive transfer from the L1.

The data partially support the assumption that prosodic strengthening has positive effects on the acquisition of certain L2 vocalic features. We predicted that prosodic prominence would result in the reinforcement of the [±rounded] and [±back] features in L2 French oral vowels, so that /y/ and /ø/ would be more clearly distinguished from /i/ and /e/ respectively in accented positions, as well as from /u/ and /o/. Statistical significance was reached only for the pair /e/~/ø/, but without interaction of participants' L1. Yet, it is worth to take a closer look at the values reported in Table 3. For Spanish and Italian learners, it seems that the effect of prosodic strengthening on the overlap of /e/~/ø/ is greater than the one observed for L1 French (Δ = 0.03 for FL1 but Δ = 0.15 and Δ = 0.18 for FL2-Spa and FL2-Ita). Although the interaction does not reach statistical significance, this trend may suggest that learners produce /ø/ more easily in accented condition, thereby confirming claims that prosodic prominence serves as a frame for the acquisition of difficult phonological features.

Regarding [i]~[y], [u]~[y] and [ø]~[o], the reinforcement of vowels in accented condition was not different from the one observed in L1 French. The values reported in Table 3 show that in many cases the effects of prosodic prominence were marginal, especially for the pairs [i]~[y] and [u]~[y] for the FL2-S and FL2-I groups.

As a whole, it seems that prosodic strengthening effects are a concomitant and natural process in L2 speech. Our results only partially confirm assumptions of the verbo-tonal method proposed by [9] that prosodic prominence facilitates the perception and production of French front rounded vowels [10]. Although this is true for [e]~[ø], our results do not show a clear tendency for the other contrasts analysed.

We conclude that prosodic prominence triggers vowel hyper-articulation in L2 speech. Yet, our data do not clearly show whether prosodic prominence reinforce L2 syntagmatic contrasts for all vowel pairs. Learners at this proficiency level may have learnt to make the contrast for [e]~[ø] in prominent (vs non-prominent) positions because in these locations there is more time for articulatory gestures to reach their target. This exploratory study partially confirmed our hypothesis and showed interesting trends that will need to be explored in the future with larger and more controlled data sets, as well as across L2 proficiency levels. Despite the considerable amount of production data analyzed, the number of learners per group is somewhat limited, and the number of target vowel occurrences vary by speaker. In addition, potential effects of speech rate were not considered in our study, and this may also be explored in the future. Finally, we acknowledge that prosodic prominence was considered mainly at the AP level. We speculate that positive effects of prosodic prominence on the acquisition of L2 features may be more clearly observed in higher prosodic units, for instance at the initial/final domains of IPs.

Table 3: Pillai Scores by target pair, prosodic condition and group, averaged over participants

	FL1			FL2-Spa			FL2-Eng			FL2-Ita		
	Unacc.	Acc.	Δ	Unacc.	Acc.	Δ	Unacc.	Acc.	Δ	Unacc.	Acc.	Δ
/i/ ~ /y/	0.36	0.41	0.05	0.57	0.57	0.00	0.34	0.42	0.08	0.62	0.72	0.10
/y/ ~ /u/	0.62	0.77	0.15	0.41	0.39	-0.02	0.38	0.42	0.04	0.45	0.50	0.05
/e/ ~ /ø/	0.29	0.32	0.03	0.18	0.33	0.15	0.25	0.34	0.09	0.21	0.39	0.18
/ø/ ~ /o/	0.33	0.63	0.30	0.17	0.37	0.20	0.42	0.38	-0.04	0.41	0.72	0.31

5. References

[1] J. Flege, "Second language speech learning: theory, findings, and problems", in W. Strange (eds), *Speech perception and linguistic experience: theoretical and methodological issues in cross-language speech research*, Timonium: York Press, 1995, pp. 233-277.

[2] C. T. Best, "A direct realist view of cross-language speech perception", in W. Strange (eds), *Speech perception and linguistic experience: Theoretical and methodological issues in cross-language speech research*, Timonium: York Press, 1995, pp. 171-204.

[3] I. Mennen, "Beyond segments: towards a L2 intonation learning theory (LILt)", in E. Delais- Roussarie, M. Avanzi and S. Herment (eds), *Prosody and language in contact. Prosody, Phonology and Phonetics*, Berlin-Heidelberg: Springer, 2015, pp. 171-188.

[4] T. Cho, "Prosodic strengthening and featural enhancement: Evidence from acoustic and articulatory realizations of /a, i/ in English", *Journal of the Acoustical Society of America*, vol. 11, n.6, 2005, pp. 3867- 3878.

[5] T. Cho, and P. Kating, "Articulatory and acoustic studies in domain-initial strengthening in Korean", *UCLA working papers in phonetics*, vol. 97, 1999, pp. 100-138.

[6] T. Cho, "The phonetics–prosody interface in laboratory phonology", in N. C. Kuma, B. Botma, and K. Nasukawa (eds), *The continuum companion to phonology*, London/New York: Continuum, 2011, pp. 243-368.

[7] C. Fougeron, "Articulatory properties of initial segments in several prosodic constituents in French", *Journal of Phonetics*, vol. 29, n.2, 2001, pp. 109-135.

[8] C. Gendrot, K. Gerdes, and M. Adda-Decker, "Impact of prosodic position on vocalic space in German and French", *Proceedings of ICPhS 2011,* Hong Kong (China), August 2011, pp.731-734.

[9] M. Billières, "Le statut de l'intonation dans l'évolution de l'enseignement/apprentissage de l'oral en FLE", *Le Français dans le Monde, Recherches et applications*, vol. 43, 2008, pp. 27-37.

[10] C. Alazard-Guiu, F. Santiago, & P. Mairano, P., "L'incidence de la correction phonétique sur l'acquisition des voyelles en langue étrangère : étude de cas d'anglophones apprenant le français," *XXXIIe Journées d'Études Sur La Parole*, Aix-en-Provence, France, Juin 2018, pp. 116–124.

[11] F. Baills, C. Alazard-Guiu, and P. Prieto, "Embodied prosodic training helps improve L2 pronunciation in an oral-reading task," *Applied Linguistics*, under review.

[12] P. Li, F. Baills, and P. Prieto, "Observing and producing durational hand gestures facilitates the pronunciation of novel vowel-length contrasts", *Studies in Second Language Acquisition*, vol. 42, n. 5, 2020, pp. 1015-1039.

[13] P. Li, X. Xi, F. Baills, L. Baqué & P. Prieto, P. "Embodied prosodic training helps improve not only accentedness but also vowel accuracy", *Language Teaching Research*, under review.

[14] J. Choi, S. Kim, and T. Cho, "Effects of L1 prosody on segmental contrast in L2: The case of English stop voicing contrast produced by Korean speakers", *Journal of the Acoustical Society of America*, v. 139, n.3, 2016, EL76-82.

[15] F. Santiago and P. Mairano, "Prosodic effects on L2 French vowels: a corpus-based investigation", *Proceedings of ICPhS2019*, Melbourne (Australia), August 2019, pp. 1084-1088.

[16] E. Delais-Roussarie and H. Yoo, "The COREIL corpus: a learner corpus designed for studying phrasal phonology and intonation", *Proceedings of 6th New Sounds*, 2010, pp. 100-105

[17] S. Herment, A. Tortel, B. Bigi, D. Hirst, and A. Loukina, "AixOx, a multi-layered learners' corpus: automatic annotation", in J. Díaz Pérez and A. Díaz Negrillo (eds), *Specialisation and variation in language corpora*, Bern: Peter Lang, 2014, pp. 41-76.

[18] E. Delais-Roussarie, T. Kupisch, P. Mairano, F. Santiago, and F. Splendido, "ProSeg: a comporable Corpus of spoken L2 French", *EuroSLA 28*, Münster, Germany, 2018.

[19] B. Post, B. *Tonal and phrasal structures in French intonation,* Hague: Holland Academic Graphics, 2000.

[20] P. Mertens, "Polytonia: a system for the automatic transcription of tonal aspects in speech corpora", *Journal of Speech Sciences*, vol. 4, n. 2, 2014, pp. 17-57.

[21] P. Mertens, "The Prosogram: Semi-Automatic Transcription of Prosody Based on a Tonal Perception Model", in *Proceedings of 2nd Speech Prosody*, Nara (Japan), 2004, pp. 23-26.

[22] J. Nycz and L. Hall-Lew, "Best practices in measuring vowel merger", in *Proceedings of the 20th Meeting on Acoustics*, 2013.

[23] P. Mairano, C. Bouzon, M. Capliez, and V. De Iacovo, "Acoustic distances, Pillai scores and LDA classification scores as metrics of L2 comprehensibility and nativelikeness, in *Proceedings of ICPhS2019*, Melbourne (Australia), August 2019, pp. 1104-1108.

[24] P. Mairano and F. Santiago, "What vocabulary size tells us about pronunciation skills: Issues in assessing learners", *Journal of French Language Studies*, vol. 30, n.2, 2020, pp. 141-160.

[25] M. Ortega-Llebaria and P. Prieto, "Disentangling stress from accent in Spanish: Production patterns of the stress contrast in deaccented syllables", in P. Prieto, J. Mascaró, and M. Josep Solé, (eds), *Segmental and Prosodic Issues in Romance Phonology*, Amsterdam/Philadelphia: John Benjamins, 2007, pp. 155-175.

[26] B. Gili Fivela, A. Stella, S. D'Apolito, and F. Sigona, "Coarticulation across prosodic domains in Italian: An ultrasound investigation", *Proceedings of 12th INTERSPEECH*, 2011, pp. 393-396.