Adaptation to L3 Phonology? Perception of the Japanese Consonant Length Contrast by Learners of Italian

Kimiko Tsukada[1, 2], *John Hajek*[2]

[1]Macquarie University, [2]The University of Melbourne
kimiko.tsukada@gmail.com, j.hajek@unimelb.edu.au

Abstract

Both Italian and Japanese use consonant length contrastively, but length contrast is known to be difficult for non-native speakers. The perception of Japanese singleton/geminate contrasts by learners of Italian from American English and Argentinian Spanish backgrounds was compared to determine if learning Italian may be helpful for processing known contrasts in an unknown language. The two groups did not differ significantly and both groups discriminated length contrasts more accurately when alveolar geminate [tː] (rather than velar singleton [k]) occurred in the target position. The results suggest that knowledge of Italian may not automatically guarantee adaptation to Japanese length processing.

Index Terms: Japanese consonant length, American English, Argentinian Spanish, Italian, second/foreign language (L2/FL)

1. Introduction

Although typologically unrelated, both Italian and Japanese use consonant length contrastively [1-3]. For example, in Italian, *eco* and *ecco* mean 'echo' and 'here (it is)', respectively. In Japanese, on the other hand, *ika* 以下 and *ikka* 一課 mean 'below' and 'lesson one', respectively. This differs from languages such as English or Spanish, neither of which has an underlying consonant length contrast at the level of words [4, 5] (with a possible exception of the tap vs trill contrast in Spanish [6]). Length contrasts are important for communication purposes as shown above, but they are known to be difficult for non-native speakers from diverse L1 backgrounds [3, 7, 8].

The question of interest in this study is whether individuals who have been exposed to Italian as opposed to Japanese consonant length may adapt themselves efficiently to Japanese consonant length. This can be characterized as the indirect influence of L2/FL (second/foreign language), rather than L1, learning on the processing/acquisition of L3 (third language) phonology. This is a novel aspect of our study, as there is still little research [9, 10] that investigates the transfer effect of L2/FL learning on L3 phonology across typologically unrelated languages such as Japanese and Italian. There is general agreement that L2 plays an important role in the L3 acquisition process, especially at the initial stage of learning [11, 12].

Japanese is a popular L2/FL in many countries including Australia and the USA. In addition to local native English-speaking learners, there are many learners from non-English-speaking backgrounds (e.g., Mandarin Chinese or Korean) in large cities such as Sydney or Melbourne in Australia. Typically, Japanese is their L3 after L2 English for these learners. It is therefore important to gain a better understanding of the processing/acquisition of difficult Japanese sounds by non-native learners from diverse linguistic backgrounds and utilize the knowledge for improving pronunciation pedagogy.

In this study, we gained access to and compared two groups of participants who had exposure to Italian but differed in their L1 (American English vs Argentinian Spanish). As neither English nor Spanish uses consonant length contrastively, it may be their shared L2/FL, Italian, rather than their respective L1s that may influence their perception of unfamiliar Japanese singleton/geminate. While L2/FL Italian learning experience may be expected to enhance consonant length perception in general, it is possible that the benefit of learning may be specific to the processing of the speech sounds of the target language, Italian. This is because some cross-linguistic differences between Italian and Japanese in consonant length have been reported. For instance, vowels preceding geminates are shorter than vowels preceding singletons in Italian [13], but longer in Japanese [14, 15]. Another example is that liquid geminates occur frequently in Italian, but not in Japanese [14].

In fact, the rate of gemination in Italian written texts has also been reported to depend on the phoneme type such that long /tː/ occurs at only 15% of the rate of short /t/, whereas long /kː/ is even less frequent at a rate of only 5% of all cases of short /k/, respectively [Table 3 in 16]. This appears to differ from the frequency of occurrence of Japanese geminates. According to [17], long /kː/ occurs at a rate of 32% of all geminate consonants, whereas long /tː/ at a rate of 28% in the corpus of a Japanese newspaper. Geminate /k/ was also more frequent than geminate /t/ in the Corpus of Spontaneous Japanese and the ratio of singleton/geminate closure duration was larger for /k/ (2.84) than for /t/ (2.38) [14]. If so, short/singleton vs long/geminate /k/ may be acoustically more salient than other contrasts in Japanese. These cross-linguistic phonetic differences may affect how learners of Italian perceive Japanese singleton/geminate consonants and we were also interested in determining if listeners' length perception accuracy varies depending on the type of consonant by comparing alveolar and velar places of articulation.

Unfortunately, at present, we do not know how our participants perceive the Italian singleton/geminate contrast, which is a serious limitation of the present study. However, the accepted wisdom is that learning to communicate efficiently in an FL is a challenge for most adults and requires a huge investment of time and effort. Therefore, we were motivated to study if and how, not only learners of Japanese, but learners of Italian may indirectly benefit from FL experience by examining known singleton/geminate contrasts in an unknown language, Japanese. We also present data collected from American English learners of Japanese for comparison.

2. Method

The experimental stimuli and procedures were identical to those used previously [18].

2.1. Stimuli preparation

2.1.1. Speakers

Six (3 males, 3 females) native speakers of Japanese participated in the recording sessions, which lasted between 45 and 60 minutes. The speakers' age ranged from late twenties to early forties. All speakers spoke standard Japanese, having been born or having spent most of their life in the Kanto region surrounding the Greater Tokyo Area [20 for references to cross-dialectal studies]. The first author (native speaker of Japanese originally from Tokyo) auditorily confirmed that all the speakers clearly differentiated the singleton and geminate consonants by duration. The speakers were recorded in the recording studio at the National Institute of Japanese Language and Linguistics, Tokyo.

2.1.2. Speech materials

Table 1 shows 12 Japanese word pairs used in this study. The /(C)VC(C)V/ tokens contained singleton (n = 96) or geminate (n = 96) consonants intervocalically (underlined). Only tokens with stops were considered in this study. As voiced geminates are disfavoured and their occurrence is limited in Japanese [14, 19, 20], only voiceless stops (/t, k/) were used. On average, the closure durations were 96 ms and 262 ms for singletons and geminates, respectively. Averaged across tokens by all speakers, the geminate-to-singleton ratios were 2.7 for alveolars (/t/-/t:/) and 2.8 for velars (/k/-/k:/), respectively. These durational values are in good agreement with what has been reported in previous research [21] (see, however, [14] for alveolars).

Table 1. *Twelve pairs of Japanese words used with target sounds underlined and bolded. HL and LH indicate High-Low and LH pitch patterns, respectively.*

	Singleton		**Geminate**	
/t/	*he**t**a*^{LH}	'unskilled'	*he**tt**a*^{LH}	'decreased'
	*ka**t**o*^{HL}	'transient'	*ka**tt**o*^{HL}	'cut'
	*ma**t**e*^{HL}	'wait'	*ma**tt**e*^{HL}	'waiting'
	*o**t**o*^{LH}	'sound'	*o**tt**o*^{LH}	'husband'
	*sa**t**e*^{HL}	'well, then'	*sa**tt**e*^{HL}	'leaving'
	*wa**t**a*^{LH}	'cotton'	*wa**tt**a*^{LH}	'broke'
/k/	*a**k**e*^{LH}	'open'	*a**kk**e*^{LH}	'appalled'
	*ha**k**a*^{LH}	'grave'	*ha**kk**a*^{LH}	'mint'
	*i**k**a*^{HL}	'below'	*i**kk**a*^{HL}	'lesson one'
	*ka**k**o*^{HL}	'past'	*ka**kk**o*^{HL}	'parenthesis'
	*sa**k**a*^{LH}	'slope'	*sa**kk**a*^{LH}	'author'
	*shi**k**e*^{LH}	'rough sea'	*shi**kk**e*^{LH}	'humidity'

2.2. Participants

Five (one native and four non-native) groups of participants took part in the AXB discrimination task. Our target groups are learners of Italian whose L1 was either American English (AE) or Argentinian Spanish (AS). The former group (AE + Italian) consisted of 7 (3 males, 4 females, *mean age* = 25.3 years, *sd* = 11.8) participants, started learning Italian at the age of 18.3 on average (*sd* = 2.0) and had a mean length of learning of 2.6 (*sd* = 2.2) years. Three of them were enrolled in the first-year, another three in the second-year, one each in the third-year and fourth-year level Italian at University of Oregon in Eugene, OR, USA. The latter group (AS + Italian) also consisted of 7 (2 males, 5 females, *mean age* = 24.0 years, *sd* = 5.8) participants. Three were in the second-year, three were in the third-year and one was at the fourth-year level. They were enrolled in the Universidad Nacional del Litoral in Sante Fe, Argentina. As the number of participants in both groups is small, the results need to be regarded as preliminary.

Two other non-native groups consisted of AE speakers who were students at University of Oregon. Some of their results were reported previously [22] and included here only for comparison. One group consisted of 19 (7 males, 12 females, *mean age* = 22.9 years, *sd* = 3.7) AE learners of Japanese (AE + Japanese) at different levels of proficiency. Two of them were heritage learners. One was enrolled in the first-year level and the other was enrolled in the third-year level Japanese. Excluding these heritage learners, the AE + Japanese listeners started learning Japanese at the age of 17.4 on average (*sd* = 5.8) and had a mean length of learning of 4.5 (*sd* = 4.1) years. The other group consisted of 17 (4 males, 13 females, *mean age* = 19.8 years, *sd* = 1.0) AE speakers inexperienced in Japanese who were enrolled in Psychology or Linguistics courses and received credit for research participation. Neither of these two AE groups had experience learning Italian formally at college level, but they differed in their experience with Japanese. However, this is not intended to guarantee that the two groups are comparable apart from Japanese experience and participants' language background needs to be more tightly controlled in future work.

The last and a control group consisted of 10 (2 males, 8 females) native speakers of Japanese (NJ) who were students at University of Oregon. All NJ speakers were born and spent the majority of their life in Japan. Their mean length of residence in the US was 0.4 years (*sd* = 0.22) at the time of participation. None of the NJ speakers participated in the recording sessions. According to self-report, all five groups of participants had normal hearing.

All participants were tested individually in a session lasting approximately 30 to 40 minutes in a sound-attenuated laboratory or a quiet room at their own university. The experimental session was self-paced. The participants heard the stimuli at a self-selected, comfortable amplitude level over the high-quality headphones on a computer.

2.3. Procedure

The participants completed a two-alternative forced-choice AXB discrimination task, in which they were asked to listen to trials arranged in a triad (A-X-B). The presentation of the stimuli and the collection of perception data were controlled by the PRAAT program [23]. In the AXB task, the first (A) and third (B) tokens always came from different length categories, and the participants had to decide whether the second token (X) belonged to the same category as A (e.g., 'yoka$_2$'-'yoka$_1$'-'yokka$_3$') or B (e.g., 'soto$_3$'-'sotto$_1$'-'sotto$_2$'; where the subscripts indicate different speakers).

The participants listened to a total of 200 trials. The first eight trials were for practice and were not analyzed. The three tokens in all trials were spoken by three different speakers. Thus, X was never acoustically identical to either A or B. This was to ensure that the participants focused on relevant phonetic characteristics that group two tokens as members of the same length category without being distracted by audible but phonetically irrelevant within-category variation (e.g., in voice quality). This was considered a reasonable measure of participants' perceptual capabilities in real world situations [24]. All possible AB combinations (i.e., AAB, ABB, BAA, and BBA, 48 trials each) were tested.

The participants were given two ('A', 'B') response choices on the computer screen. They were asked to select the option 'A' if they thought that the first two tokens in the AXB sequence were the same and to select the option 'B' if they thought that the last two tokens were the same. They were informed that they would hear words from languages which may be unfamiliar to them, but they were not explicitly instructed to listen for the difference in consonant length. No feedback was provided during the experimental sessions. The participants could take a break after 50 trials if they wished (information on this is available, but not analyzed). The participants were required to respond to each trial, and they were told to guess if uncertain. A trial could be replayed as many times as the participants wished in order to reduce their anxiety, but responses could not be changed once given. The interstimulus interval in all trials was 0.5 s.

3. Results

We used R version 3.6.0 for preliminary statistical analyses and data visualization reported below [25]. The packages used include ez [26] and tidyverse [27].

3.1. Overall results

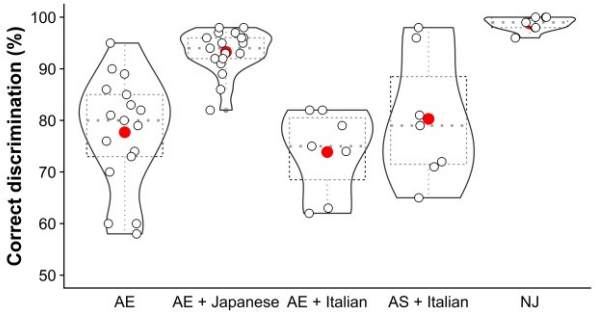

Figure 1: *The distributions of length discrimination accuracy (%) by five groups of participants. The horizontal line and the red circle in each box indicate the median and mean, respectively.*

Figure 1 shows the distributions of percentages of correct discrimination by the five groups of participants. The overall mean discrimination accuracy for non-native participants was 78%, 93%, 74% and 80% for the AE, AE + Japanese, AE + Italian and AS + Italian groups, respectively. The NJ group was at near ceiling (99%) with little individual variation. It is clearly visible that the AE + Japanese group with direct learning experience outperformed the other non-native groups. For AE listeners (i.e., AE vs AE + Italian), it appears that learning Italian with singleton/geminate contrasts did not positively transfer to the perception of consonant length in unfamiliar Japanese. A direct comparison of our two target groups of learners of Italian, AE + Italian and AS + Italian, via the Welch two-sample *t*-test showed that the between-group difference was not significant [$t(10.43) = -1.1$, $p = 0.29$].

3.2. Comparison of the direction of category change (Geminate > Singleton or Singleton > Geminate)

Next, we compared the results for the trials in which the consonant length in the AXB sequence changed from 1) geminate (G) to singleton (S) (i.e., G-G-S, G-S-S) or 2) S to G (i.e., S-S-G, S-G-G), focusing on the two target groups. This analysis would enable us to evaluate if the participants detected a change in length category bi-directionally or not. Figure 2 shows the distributions of percentages of correct discrimination by the two groups of learners of Italian as a function of the direction of category change within a trial (G > S, S > G). The AE + Italian group showed nearly identical discrimination accuracy whether the direction of change was from G to S (74%) or from S to G (73%). The AS + Italian group, on the other hand, was slightly more accurate when the direction of change was from S to G (83%) than when it was from G to S (79%). Two-way analysis of variance (ANOVA) with group (AE + Italian, AS + Italian) as a between-subjects factor and direction of category change (G > S, S > G) as a within-subjects factor did not reach significance for the main effects nor the interaction effect.

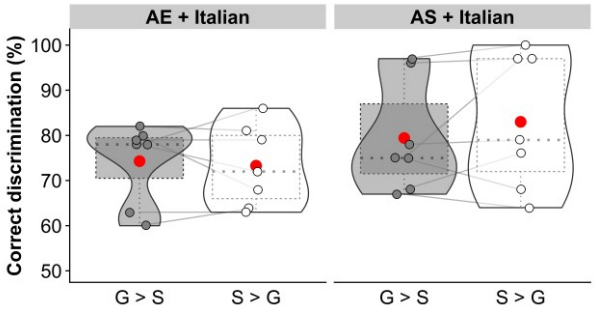

Figure 2: *The distributions of length discrimination accuracy (%) by two groups of learners of Italian for trials differing in the direction of category change (Geminate > Singleton, Singleton > Geminate). The light lines connect individual participants' scores.*

3.3. Comparison of the length category (Geminate vs Singleton) of the target token (X in AXB)

In the AXB discrimination task, the identity of the token placed in the target position may affect the participants' discrimination accuracy. Figure 3 shows the distributions of percentages of correct discrimination by the two groups of learners of Italian as a function of the length category of the target token (geminate vs singleton).

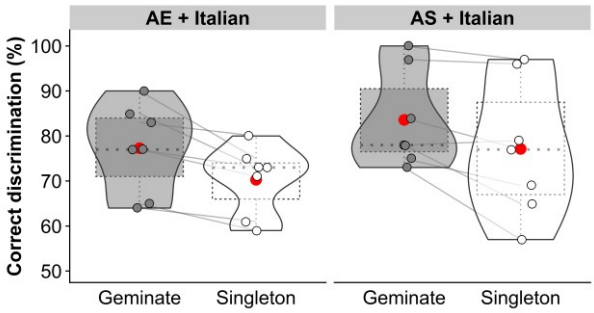

Figure 3: *The distributions of length discrimination accuracy (%) by two groups of learners of Italian for trials differing in the length category of the target token (Geminate, Singleton).*

When the length category of the target token (i.e., X in the AXB sequence) was taken into consideration, both groups were more accurate when the target consonant was a geminate than when it was a singleton (AE + Italian: 77% vs 70%, AS + Italian: 84% vs 77%). Two-way ANOVA with group (AE + Italian, AS + Italian) as a between-subjects factor and length (geminate, singleton) as a within-subjects factor reached

significance only for the main effect of length [$F(1, 12) = 20.8$, $p < 0.001$, $\eta_G^2 = .09$]. The lack of significant interaction suggests that both groups discriminated length contrasts more accurately when the target consonant was a geminate than when it was a singleton.

3.4. Comparison of length discrimination at alveolar (/t/-/tː/) and velar (/k/-/kː/) places of articulation

As mentioned in the Introduction, the relative frequency of consonants occurring as geminates appears to differ between Italian and Japanese. Of relevance to the present study, /tː/ occurs more frequently than /kː/ in Italian, but the reverse seems to be the case in Japanese. Given this cross-linguistic difference in distributional frequency, in this section, we provide an analysis of whether or not the place of articulation (i.e., alveolar vs velar) may affect listeners' length discrimination accuracy. Figure 4 shows the distributions of percentages of correct length discrimination by the two groups of learners of Italian and a group of learners of Japanese as a function of the place of articulation (alveolar vs velar) and the length category (geminate, singleton) of the target token.

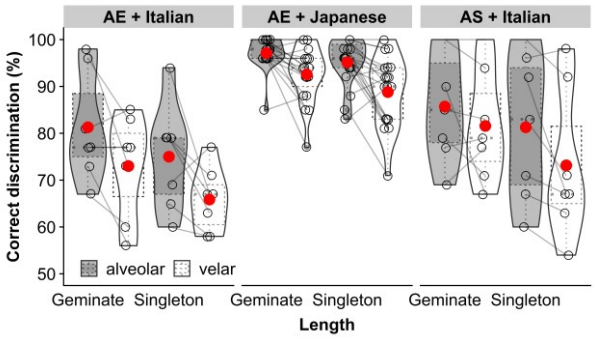

Figure 4: *The distributions of length discrimination accuracy (%) by two groups of learners of Italian and a group of learners of Japanese for trials differing in the place of articulation of the target token (alveolar, velar).*

When the place of articulation (alveolar vs velar) of the target token was taken into consideration, all three groups more accurately discriminated consonant length when the target consonant was alveolar than when it was velar (AE + Italian: 78% vs 69%, AE + Japanese: 96% vs 91%, AS + Italian: 83% vs 77%). This held true for both length categories as shown in Figure 4 (AE + Italian: 81% vs 73% for geminate, 75% vs 66% for singleton, AE + Japanese: 97% vs 93% for geminate, 95% vs 89% for singleton, AS + Italian: 86% vs 82% for geminate, 81% vs 73% for singleton). Three-way ANOVA with group (AE + Italian, AE + Japanese, AS + Italian) as a between-subjects factor and length (geminate, singleton) and place (alveolar, velar) as within-subjects factors reached significance for the main effects of group [$F(2, 30) = 20.0$, $p < 0.001$, $\eta_G^2 = .49$], length [$F(1, 30) = 29.0$, $p < 0.001$, $\eta_G^2 = .06$] and place [$F(1, 30) = 50.9$, $p < 0.001$, $\eta_G^2 = .12$] only. No interactions were significant. The lack of significant interactions suggest that the effects of length and place were comparable for all three groups despite different L2/FL learning backgrounds.

4. Discussion

This study examined the perception of Japanese consonant length contrasts by learners of Italian whose L1 was American English (AE + Italian) or Argentinian Spanish (AS + Italian). We were interested in determining whether individuals who were exposed to Italian consonant length may adapt themselves efficiently to consonant length in an unfamiliar language. As the number of participants in each group is small, the data are still preliminary. The two groups of learners of Italian did not differ significantly from each other and were much less accurate than native and non-native speakers of Japanese (Figures 1 and 4). Further, both AE + Italian and AS + Italian (and AE + Japanese) groups discriminated length contrasts more accurately when a geminate or alveolar stop rather than a singleton or velar stop occupied the target (X) position in the AXB sequence. This resulted in a hierarchy of discriminability with [tː] at the top and [k] at the bottom (Figure 4).

The participants' lack of adaptation to Japanese singleton/geminate may be related to cross-linguistic differences (e.g., duration of adjacent vowels, etc.) in how Italian and Japanese consonant length contrasts are realized. It is difficult to hypothesize that the place effect observed in this study is related to the frequency distribution of Italian consonants that occur as geminates [16]. This is because AE + Japanese who were inexperienced in Italian showed the same pattern of results as the two groups of learners of Italian (Figure 4). While the stimuli used in the present study had almost identical geminate-to-singleton ratios for both stops (2.7 for alveolars and 2.8 for velars, respectively), there may be some acoustic phonetic characteristics other than durational ratios that make the velar consonant hard to perceive as pointed out by one reviewer. In this connection, previous research reported that the geminate /t/ was less accurately perceived than the geminate /s/ by native speakers of German despite larger geminate-to-singleton ratios for the former than the latter [28].

What is crucially lacking in this study is how these participants perceive Italian singletons and geminates. In future work, it is necessary to examine participants' consonant length processing in both familiar and unfamiliar languages to assess if and how consonant length perception is related in known and unknown languages. It is also necessary to increase the number of participants and further investigate how the proficiency of Italian may affect the perception of both Italian and Japanese consonant length contrasts. Unlike Italian, both vowel as well as consonant length is contrastive in Japanese and both short and long vowels can precede singletons and geminates. It would be interesting to examine how phonological vowel length (as opposed to phonetic vowel lengthening) may influence the perception of the length category of the following consonants.

5. Conclusions

The learners of Italian from American English and Argentinian Spanish backgrounds did not differ from each other in discriminating consonant length contrasts in Japanese. This may be because they lack specific knowledge of the phonetic characteristics of Japanese singletons and geminates. Both groups also discriminated length contrasts more accurately when alveolar geminate [tː] (rather than velar singleton [k]) occurred in the target position. The results suggest that experience with Italian singletons and geminates may not automatically transfer to the efficient processing of Japanese singletons and geminates.

6. Acknowledgements

This work is supported by the 2018 Endeavour Research Fellowship and the Sumitomo Foundation Fiscal 2020 Grant for Japan-related Research Projects awarded to the first author. We

thank Kaori Idemaru for the use of Spoken Language Research Laboratories and participants for making the study possible. We also thank three anonymous reviewers for their constructive comments and suggestions for improving this work.

7. References

[1] Vance, T. J., The Sounds of Japanese. Cambridge: Cambridge University Press, 2008.
[2] Rogers, D. and d'Arcangeli, L. "Italian", Journal of the International Phonetic Association, 34(1): 117-121, 2004.
[3] De Clercq, B., Simon, E. and C. Crocco, C., "Rosa versus rossa: The acquisition of Italian geminates by native speakers of Dutch", Phrasis: Studies in Language and Literature, 2: 3-29, 2014.
[4] Kaye, A. S., "Gemination in English", English Today, 21: 43-55. 2005.
[5] Oh, G. E. and Redford, M. A., "The production and phonetic representation of fake geminates in English", Journal of Phonetics, 40: 82-91, 2012.
[6] Cordero, D., Ruiz-Peña, E., Sierra, E., Stevenson, R. and Rafat, Y., "Second dialect and second language imitation of geminates by Colombian Spanish speakers", in E. Babatsouli [Ed], Proceedings of the International Symposium on Monolingual and Bilingual Speech 2017, 99-105, 2017.
[7] Han, M. S., "The timing control of geminate and single stop consonants in Japanese: A challenge for non-native speakers", Phonetica, 49: 102-127, 1992.
[8] Kubozono, H., "Introduction to the special issue on Japanese geminate obstruents", Journal of East Asian Linguistics, 22: 303-306, 2013.
[9] Cabrelli Amaro, J. and Wrembel, M., "Investigating the acquisition of phonology in a third language: A state of the science and an outlook for the future", International Journal of Multilingualism, 13(4): 395-409, 2016.
[10] Magdalena, W., Marecka, M. and Kopečková, R., "Extending perceptual assimilation model to L3 phonological acquisition", International Journal of Multilingualism, 16(4): 513-533, 2019.
[11] Gut, U., "Cross-linguistic influence in L3 phonological acquisition", International Journal of Multilingualism, 7(1): 19-38, 2010.
[12] Wrembel M., "L2-accented speech in L3 production", International Journal of Multilingualism, 7(1): 75-90, 2010.
[13] Hajek, J., Stevens, M. and Webster, G. "Vowel duration, compression and lengthening in stressed syllables in Italian", Proceedings of the 16th ICPhS, 1057-1060, 2007.
[14] Sano, S., "The distribution of singleton/geminate consonants in spoken Japanese and its relation to preceding/following vowels", Proceedings of 19th ICPhS, 1833-1837, 2019.
[15] Idemaru, K. and Guion-Anderson, S., "Relational timing in the production and perception of Japanese singleton and geminate stops", Phonetica, 67, 25-46, 2010.
[16] Arango, J., DeCaprio, A., Baik, S., De Nardis, L., Shattuck-Hufnagel, S. and Di Benedetto, M.-G., "Estimation of the frequency of occurrence of Italian phonemes in text", Online: https://arxiv.org/pdf/2101.06147.pdf (accessed on June 7, 2022).
[17] Tamaoka, K. and Makioka, S., "Frequency of occurrence for units of phonemes, morae, and syllables appearing in a lexical corpus of a Japanese newspaper", Behavior Research Methods, Instruments, & Computers, 36(3): 531-547, 2004.
[18] Tsukada, K., Yurong, Kim, J.-Y., Han, J.-H. and Hajek, J., "Cross-linguistic perception of the Japanese singleton/geminate contrast: Korean, Mandarin and Mongolian compared", Proceedings of 22nd Interspeech, 3910-3914, 2021.
[19] Hussein, Q. and Shinohara, S., "Partial devoicing of voiced geminate stops in Tokyo Japanese", The Journal of the Acoustical Society of America, 145: 149-163, 2019.
[20] Kawahara, S., "The phonetics of sokuon, or geminate obstruents", in H. Kubozono [Ed], Handbook of Japanese Phonetics and Phonology, 43-78, Berlin: Walter de Gruyter, 2015.
[21] Hayes-Harb, R., "Optimal L2 speech perception: Native speakers of English and Japanese consonant length contrasts", Journal of Language and Linguistics, 4: 1-29, 2005.
[22] Tsukada, K., Idemaru, K. and Hajek, J., "The effects of foreign language learning on the perception of Japanese consonant length contrasts", Proceedings of 17th SST, 37-40, 2018.
[23] Boersma, P. and Weenink, D., Praat: Doing Phonetics by Computer [version 6.0.19], retrieved from http://www.praat.org (Last viewed June 13, 2016).
[24] Strange, W. and Shafer, V. L., "Speech perception in second language learners: The re-education of selective perception", in J. G. Hansen Edwards and M. L. Zampini [Eds], Phonology and Second Language Acquisition, 153-191, John Benjamins, 2008.
[25] R Core Team, R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/ 2019.
[26] Lawrence, M. A. ez: Easy Analysis and Visualization of Factorial Experiments. R package version 4.4-0. https://CRAN.R-project.org/package=ez 2016.
[27] Wickham, H., Averick, M., Bryan, J., Chang, W., McGowan, L. D., François, R. et al., "Welcome to the tidyverse", Journal of Open Source Software, 4(43): 1686. 2019.
[28] Oba, R., Braun, A. and Handke, J., "The perception of Japanese geminates by native and non-native listeners", The Phonetician, 92: 9-29, 2005.