Non-native Japanese learners’ perception of consonant length in Japanese and Italian

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Abstract: Learners of a foreign language (FL) typically have to learn to process sounds that do not exist in their first language (L1). As this is known to be difficult for adults, in particular, it is important for FL pedagogy to be informed by phonetic research. This study examined the role of FL learners’ previous linguistic experience in the processing of a contrast absent in the L1. The FLs under investigation are Japanese and Italian which both use contrastive consonant length. Two groups of non-native Japanese (NNJ) learners – L1 Australian English (OZ) and L1 Korean – participated in the consonant length identification task. Neither OZ nor Korean has an underlying consonant length contrast, but Korean has non-constrastive lengthening of tense obstruents with corresponding shorter preceding vowels, which may be beneficial in perceiving consonant length in an FL. We have taken a novel, two-stage approach. First, we compared the perception of Japanese long/geminate and short/singleton consonants by the two groups of NNJ learners. Second, we investigated whether FL Japanese learning by the two groups transfers to the processing of consonant length in an unknown language, Italian. Native speakers of Japanese (NJ) and Italian (NI) were included as controls. They were familiar with contrastive consonant length in their L1, but were naïve to the other language. The NJ and NI groups accurately identified the consonant length category in their L1 but were slightly less accurate in the unknown language. The two NNJ groups were generally accurate (> 80%) in perceiving consonant length not only in Japanese, but also in Italian. However, the direction of NNJ learners’ misperception (i.e. singleton as geminate or geminate as singleton) varied, suggesting that some learners, according to their L1, may categorize length in Japanese and Italian differently rather than uniformly applying the concept of [±long].
Abstract

Learners of a foreign language (FL) typically have to learn to process sounds that do not exist in their first language (L1). As this is known to be difficult for adults, in particular, it is important for FL pedagogy to be informed by phonetic research. This study examined the role of FL learners’ previous linguistic experience in the processing of a contrast absent in the L1. The FLs under investigation are Japanese and Italian which both use contrastive consonant length. Two groups of non-native Japanese (NNJ) learners – L1 Australian English (OZ) and L1 Korean – participated in the consonant length identification task. Neither OZ nor Korean has an underlying consonant length contrast, but Korean has non-constrastive lengthening of tense obstruents with corresponding shorter preceding vowels, which may be beneficial in perceiving consonant length in an FL. We have taken a novel, two-stage approach. First, we compared the perception of Japanese long/geminate and short/singleton consonants by the two groups of NNJ learners. Second, we investigated whether FL Japanese learning by the two groups transfers to the processing of consonant length in an unknown language, Italian. Native speakers of Japanese (NJ) and Italian (NI) were included as controls. They were familiar with contrastive consonant length in their L1, but were naïve to the other language. The NJ and NI groups accurately identified the consonant length category in their L1 but were slightly less accurate in the unknown language. The two NNJ groups were generally accurate (> 80%) in perceiving consonant length not only in Japanese, but also in Italian. However, the direction of NNJ learners’ misperception (i.e. singleton as geminate or geminate as singleton) varied, suggesting that some learners, according to their L1, may categorize length in Japanese and Italian differently rather than uniformly applying the concept of [±long].

Keywords: cross-language speech perception, consonant length contrasts, singleton/geminate, Japanese, Italian, non-native Japanese learners
1. Introduction

Contrastive use of length for consonants (specifically nasals and obstruents) is one of the most prominent characteristics of Japanese phonetics and phonology (Fujisaki et al., 1973; Kawahara, 2015; Kubozono, 2013; Vance 2008). For example, /kite/ (with a High-Low (HL) pitch pattern) coming contrasts with /kitte/ (HL) cutting. As is the case with many other languages, duration is the primary (though not the only) acoustic cue to differentiate the short and long members of the length contrast in Japanese (e.g. Fujisaki et al., 1973; Kawahara, 2015). According to Kubozono (2013, p. 303), “geminate obstruents (GOs) and so-called unaccented words are the two properties most characteristic of Japanese phonology and the two features that are most difficult for foreign learners of Japanese to learn, regardless of their native language”. Numerous studies have confirmed that consonant length contrasts pose learning difficulties for non-native Japanese (NNJ) learners from diverse first language (L1) backgrounds (e.g. English: Han, 1992; Harada, 2006; Toda, 2007; Indonesian: Najoan et al., 2012; Korean: Sonu et al., 2013; Hung, 2012; Mandarin: Lu et al., 2016; Uchida, 1993).

The overall objective of the present research is to add to the current understanding of consonant length perception by comparing NNJ learners from two L1s – Australian English (NNJ-OZ, n=12) and Korean (NNJ-Korean, n=10). Neither L1 has an underlying consonant length contrast, but Korean has non-contrastive lengthening of tense obstruents with corresponding shorter preceding vowels, which may confer an advantage in perceiving short/singleton and long/geminate consonants in an FL. The NNJ learners’ perception was compared with that of native speakers from two L1s – Japanese (NJ, n=10) and Italian (NI, n=14) that do have an underlying contrast in consonant length. The aims are firstly to compare NNJ learners’ ability to identify consonant length contrasts in Japanese as an FL; and secondly to determine the extent to which the same NNJ learners may be able to harness the length cue when responding to an unknown language, Italian.
Despite the importance of consonant length contrasts in Japanese and in other languages, experimental phoneticians dealing with cross-linguistic perception of consonants have tended to focus more on voicing and/or place contrasts (e.g. Hume et al., 1999; Lisker & Abramson, 1964; Tsukada, 2006; Tsukada & Roengpitya, 2008) rather than on length contrasts. In general, length contrasts may be difficult to acquire (e.g. Han, 1992), because they are not as frequent cross-linguistically or as robust as other phonetic contrasts such as the voicing contrast (e.g. *tip* vs *dip*) which is supported by as many as 16 co-varying acoustic cues (Lisker, 1986).

Currently, nearly four million NNJ learners study Japanese in and outside Japan (The Japan Foundation, 2012). The majority of these learners come from Asia-Pacific countries: 26.3% (1,046,490) from China, 21.9% (872,411) from Indonesia, 21.1% (840,187) from Korea and 7.4% (296,672) from Australia. As the L1s of most learners do not employ length contrasts in the way Japanese does, difficulty in producing and/or perceiving consonant length contrasts in Japanese is predicted and frequently witnessed inside and outside the classroom (Toda, 2007). Accurate processing of such length contrasts is required for correct grammar (e.g. /ta/ suffixed as a high frequency past tense marker in /kataː/ *bought* if the pitch-accent type is Low-High (LH) or *won* if it is HL) and for basic vocabulary (e.g. /gakːo/ *school*, /kitce/ (with a LH pitch pattern) *stamp*) and is essential to successful Japanese language acquisition (Toda, 2003, 2007). Geminates also appear frequently in emphatic speech, e.g. /totːemo/ *extremely* for /totem/o *very* (Toda, 2007) or to intensify the meaning of adjectives, e.g. /kataː/ *very hard* for /katai/ *hard*, /kusai/ *very smelly* for /kusai/ *smelly* (Kawahara, 2015; Kawahara & Braver, 2014). It is therefore critical that effective pedagogy, based on a detailed understanding of the phonetic features involved, is available to enhance NNJ learners’ communicative efficiency in perceiving and producing spoken Japanese.

Despite a large number of NNJ learners in Australia, phonetic research on their pronunciation of FL
Japanese is limited (see e.g. Kato & Cox, 2006, 2011; Toda, 2003, 2007; Tsurutani, 2007, 2008 for exceptions). NNJ learners in Australia come from a diverse range of L1 backgrounds and are not restricted to native speakers of Australian English (OZ). In fact, the majority of the NNJ learners at university level in Australian cities such as Sydney are native speakers of other Asian languages such as Korean or Mandarin, for whom Japanese may be a third language (L3) after English as a second language (L2) (Thomson, 2011; Tsukada, 2012). Thus, in order to better understand how Japanese consonant length is perceived by listeners from different L1 backgrounds, we compared two groups of NNJ learners (L1: OZ and Korean) with control groups of L1 Japanese (NJ) and L1 Italian (NI) listeners.

Neither OZ nor Korean uses consonant length contrastively and therefore we predicted that the learners would be less accurate than NJ listeners in perceiving Japanese short (singleton) and long (geminate) consonants. However, the two groups of NNJ learners may show not only lower accuracy than NJ listeners but also qualitatively different patterns of length perception from NJ listeners on the one hand, and from each other on the other hand. In other words, there may be a measurable effect of L1 on the perception of Japanese singletons and geminates as a result of phonetic differences in their respective L1s.

While Korean is not regarded as having an underlying system of contrastive consonant length, so-called tense obstruents (which contrast with plain lax and aspirated voiceless stops) show, amongst a range of phonetic cues, significant phonetic (geminate-like) lengthening in intervocalic position, unlike other stop types (Lee, 2011). Nativization of Japanese loanwords into Korean (e.g. Japanese /ipai/ fully adapted as Korean /ip’ai/ with a tense stop) also points to a regular association between Japanese geminate stops with Korean tense obstruents (Lee, 2011). Australian English makes no use of contrastive consonant length distinctions or geminate-like phonetic lengthening within words.

Following Antoniou et al. (2015), the varying use of consonant length, even at a phonetic level, in
the NNJ learners’ L1s may affect their sensitivity to this phonological feature and may therefore lead to between-group differences in their acquisition of Japanese consonant length. Our initial prediction, therefore, is that the Korean L1 listeners may be more accurate than their OZ counterparts in the perception of geminates in Japanese, and also in Italian.

We should also point out that while geminates are typically considered to be ‘marked’ and problematic in FL Japanese speech learning as mentioned above, some researchers have observed that NNJ learners produce ‘default’ singletons that sound too long to NJ listeners (Harada, 2006; Minagawa-Kawai & Kiritani, 1998; Toda, 2007). Regardless of which length category has the ‘unmarked’ status in NNJ learners’ cognitive representations, the above observation suggests a bias or difference in the direction of misperception of length, which we may also find in our results.

Another factor that has been shown to affect the production/perception of Japanese consonant length is pitch accent (Kubozono et al., 2011; Ofuka, 2003). Previous studies on FL Japanese acquisition showed that Korean, Taiwanese Mandarin and Thai learners were differentially affected by the accent type when they identified words and/or non-words containing a singleton or geminate (Hung, 2012; Minagawa & Kiritani, 1996, see, however, Harada, 2006 for English-speaking children in an immersion program) possibly due to the shorter post-consonantal vowel duration in the HL than in the LH accent type. The NNJ learners in Minagawa and Kiritan (1996) misperceived singletons as geminates more frequently when the accent pattern was HL than when it was LH. Conversely, their misperception of geminates as singletons was more frequent when the accent type was LH than when it was HL. Therefore, in this study it is important for the pitch accent type to be considered in the examination of geminate/singleton misperceptions.

We also seek to determine whether or not native speakers of another language with contrastive consonant length, Italian, may be able to utilize their L1 knowledge and outperform the NNJ learners in cross-language perception of Japanese consonant length despite their lack of Japanese
knowledge. While vowel length is not contrastive in Italian, unlike in Japanese, consonant length is contrastive for a wide variety of phonemes (/p b t d k g m n r ŋ ñ f v s l/) including the voiced obstruents which are disfavoured in Japanese (e.g. /leɡa/ ‘(he) ties’ (present indicative) vs /leɡɡa/ ‘(he) reads’ (present subjunctive) (Esposito & Di Benedetto, 1999; Payne, 2005; Rogers & d’Arcangeli, 2004). Adult NI speakers are therefore expected to possess fully developed cognitive representations for consonant length categories in their L1 Italian. On the other hand, cross-linguistic differences in phonetic realizations of Japanese and Italian singletons and geminates have also been reported (Kubozono, 2013). Specifically, in Japanese, vowels tend to be phonetically longer before geminate obstruents than before their single counterparts (Han, 1992; Idemaru & Guion, 2008), contrary to a marked cross-linguistic preference for closed syllable vowel shortening (Maddieson 1985). In Italian, on the other hand, vowels preceding geminates are known to be shorter (by up to 37%) than vowels preceding singletons (Hajek et al., 2007; Payne, 2005). Thus, an interesting theoretical question arises as to whether differences in the phonetic implementation of L1 length categories might help or hinder NI speakers when processing consonant length in an unknown language, Japanese. Also, vowels preceding tense obstruents in Korean are shorter than those before plain lenis contexts (Johnson & Oh, 1995), an effect which is similar to Italian. This raises the interesting possibility that NNJ-Korean learners may harness this knowledge from their L1 when perceiving Italian consonant length and may therefore perform better than NNJ-OZ.

With regard to influential models of cross-language and L2 speech perception, the perceptual assimilation model (PAM) (Best, 1995) and its extension, PAM-L2 (Best & Tyler, 2007), predict discrimination accuracy for pairs of non-native sounds on the basis of the perceived relationship between them. According to PAM and PAM-L2, if two speech sounds are perceptually assimilated to two distinct categories in the listeners’ L1, they will be accurately discriminated. Another well-
known model, the Speech Learning Model (SLM) (Flege, 1995, 2003), focuses on how individual non-native sounds are perceptually related to L1 sounds and seeks to identify factors that affect the extent to which they can be eventually learned across the lifespan. According to SLM, if the degree of perceived dissimilarity between the L1 and L2 sounds is large, with experience, non-native learners will overcome initial difficulty and eventually learn the new L2 sounds accurately. Neither the PAM(-L2) nor the SLM would predict perception difficulties for NI speakers listening to Japanese singleton and geminate consonants if experience with the [±long] feature is transferable and there is a good match between Japanese and Italian consonants with respect to length. However, it is not yet clear if this expected perceptual equivalence might be upheld between these two languages in the presence of cross-linguistic phonetic implementation differences briefly mentioned above.

Furthermore, we seek to determine whether or not the listening skill gained in learning FL Japanese consonant length contrast might transfer positively to the processing of consonant length in an unknown language, Italian. This is a novel aspect of our study, as there is still very little research (Cabrelli Amaro & Wrembel, 2016) that investigates the transfer effect of FL learning to the phonology of L3\(^1\), in particular, across typologically unrelated languages such as Japanese and Italian and in the context of speech perception. Studies have reported various factors including L1 and/or L2 phonology, language distance/status, extent of learners’ bilingualism, typological similarity across previously learned languages and so forth that affect L3 processing/learning (e.g. Gallardo del Puerto, 2007; Llama et al., 2010; Marx & Mehlhorn, 2010). There is general agreement that L2 plays an important role in this process, especially at the initial stage of learning a new language (Gut, 2010, Wrembel, 2010).

\(^1\) The precise definition of L3 has proven to be complex in the literature (De Bot & Jaensch, 2015; Rothman et al., 2013). We do not wish to enter into discussion here on this point, but merely take the position that an unknown language also falls within the broader remit of L3, i.e. it can be seen as the onset of acquisition of an additional language beyond L1 and L2.
Understandably, most FL phonetic studies focus on how non-native learners from different L1s and/or at different proficiency levels process and ultimately acquire difficult sounds in the target language(s). However, learning to efficiently communicate in an FL is a challenge for most adults and requires a huge investment of time and effort. It is therefore important to gain a better understanding of whether FL learning benefits just the target language(s) or whether there may be additional potentially facilitative effects for processing unfamiliar/unknown language(s). This motivated us to study NNJ learners’ perception of consonant length in unfamiliar/unknown Italian as well as their FL Japanese.

Length contrast perception is a topic that has attracted interest among scholars in FL perception and learning (e.g. Altmann et al., 2012; Bohn, 1995; Cebrian, 2006; Pajak & Levy, 2014). The knowledge gained from the present research will advance our current understanding of not only L1 but also FL transfer effects in cross-language speech perception and language learning.

In summary, this study aims to answer the following questions:

1) Do the NNJ learners whose L1s are OZ or Korean (neither of which has an underlying consonant length contrast) differ from the control groups (NJ, NI) in the overall accuracy of perception of consonant length in Japanese and Italian?

2) Do the NNJ learners (OZ and Korean) differ from each other in perceiving consonant length in Japanese and Italian? In particular, will NNJ-Korean learners with their L1 experience of non-contrastive phonetic lengthening of tense obstruents have an advantage over NNJ-OZ learners (with no evidence of any contrast of significant consonant lengthening) in perceiving FL Japanese and Italian consonant length? In addition, will NNJ-Korean learners have an additional advantage in perceiving Italian length contrast because tense (longer) obstruents in Korean are realised with shorter preceding vowels as is the case in Italian?
3) Do the four groups differ in the direction of misperception (singletons perceived as geminates and vice versa)?

4) For the Japanese stimuli, do the four groups differ in how they respond to tokens varying in pitch accent type (HL vs LH)?

5) Does learning Japanese facilitate perception of length contrasts generally? If so, we would expect FL Japanese learning to positively transfer to the processing of Italian consonant length and expect NNJ learners to perform well in perceiving not only Japanese but also Italian. If, on the other hand, FL Japanese learning interferes with cross-linguistic speech perception, NNJ learners would show a different pattern of perceptual accuracy for consonant length in Japanese and Italian.

2. Methods

2.1. Speech materials

Tables 1 and 2 show Japanese and Italian words and non-words used in this study. Of the 144 Japanese items analysed, 140 (or 97%) were real words. The Italian stimuli included a larger proportion of non-word items (30 out of 54 items analysed or 56%). The */CVC/CV/ tokens contained singleton or geminate consonants intervocalically. As reviewed in the Introduction section, the accent type (HL and LH) has been reported to affect native and non-native listeners’ length perception in Japanese (Hung, 2012; Minagawa & Kiritani, 1996; Ofuka, 2003), so Japanese tokens with both HL and LH were included in the stimuli (Table 1). In order to determine whether or not the findings previously reported can be replicated for our NNJ learners in the FL environment, we provide preliminary analyses of the pitch accent type and direction of misperception (i.e. singleton perceived as geminate and vice versa) in the present study.

Only tokens with stops and affricates (/t kʧ/ for Japanese (Table 1) and /p t k b d ɡ dʒ/ for Italian (Table 2)) were considered in this study. As voiced geminates are limited in Japanese, only voiceless
consonants were used in the Japanese stimuli. To record the stimuli to be used in the perceptual study, each word was presented on a computer screen in random order and produced in two separate conditions: one in isolation and the other in a carrier sentence (/sokowa _____ to jomimasu/ You read it as _____ there for Japanese and /diko ______di nwɔvo/ I say ____ again for Italian). The pace of presentation was controlled by the experimenter (the first author). The speech materials were digitally recorded at a sampling rate of 44.1 kHz and the target words were segmented and stored in separate files. To avoid inter-speaker variation in fluency (specifically, the duration of a pause before and after the target word), only tokens produced in isolation were used as experimental stimuli in this study.

Table 1 about here

Table 2 about here

Seven NJ speakers (4 males, 3 females) and three NI speakers (2 males, 1 female) participated in the recording sessions, which lasted between 45 and 60 minutes. The speakers’ age ranged from late 20s to early 60s. According to self-report, which was confirmed by the first author who is a NJ speaker originally from Tokyo, all NJ speakers spoke standard Japanese, having been born or having spent most of their life in the Kanto region surrounding the Greater Tokyo Area. Speakers were recorded in the recording studio at the National Institute of Japanese Language and Linguistics (NINJAL), Tokyo except for one speaker who was recorded in Sydney. The three NI speakers came from different parts of Italy (including Rome and Sicily) and are long-term residents of Sydney. They were recorded in the audio-visual recording studio at a university in Sydney. One of the authors with expertise in Italian phonetics/phonology confirmed that the three NI speakers clearly differentiated the singleton and geminate consonants by length. All three NI speakers were highly
experienced university teachers of Italian with a clear understanding of pronunciation norms. All recorded participants received AUS$20 (or equivalent in Japanese yen) for their time.

2.2. Listeners

Perception data were collected from four groups of listeners differing in their L1. Table 3 shows the group structure and their L1 characteristics with respect to length contrasts.

Table 3 about here

The two experimental groups consisted of NNJ learners whose L1 was OZ (NNJ-OZ, 3 males, 9 females, \(\text{mean} = 21.2\) years, \(sd = 4.7\)) or Korean (NNJ-Korean, 4 males, 6 females, \(\text{mean} = 22.4\) years, \(sd = 5.0\)). The NNJ learners participated in the study in their home countries: the NNJ-OZ learners were tested at universities in Australia and the NNJ-Korean learners were tested at a university in Seoul, Korea. All NNJ learners were recruited from the undergraduate student populations at each institution.

It is difficult to objectively control learners’ level of proficiency in FL speech research due to large individual variation and to different curricula at different institutions. The NNJ learners in the present study were enrolled in the pre-intermediate to advanced Japanese language course (approximately 180 – 540 hours of instruction) at each university. Based on assessment of L2 learning hours, the self-reported language background questionnaire as well as informal verbal interaction with the first author who teaches Japanese at the tertiary level, the two NNJ groups were perceived to be roughly comparable. None of the NNJ learners had prior knowledge of Italian.

The two control groups consisted of ten NJ speakers (5 males, 5 females, \(\text{mean} = 25.5\) years, \(sd = 6.9\)) and 14 NI speakers (5 males, 9 females, \(\text{mean} = 35.5\) years, \(sd = 10.0\)). The NJ and NI
listeners had no command of each other’s language. They were recruited from the student/staff populations at universities or from the local communities in Australia (NJ and NI listeners) and Japan (NJ listeners). Having identified themselves as NJ or NI, all participants were tested individually in a quiet room or sound-attenuated studio at each institution and received AUS$20 (or equivalent) for their participation.

2.3. Task

The listeners participated in a forced-choice identification task and listened to a total of 252 (84 x 3 blocks) Japanese tokens followed by one block of 84 Italian tokens. In preparing the stimuli, care was taken so that the distribution of the speakers within each block would be as even as possible. Of all the stimuli presented, a subset (i.e., 144 Japanese tokens and 54 Italian tokens with stops and affricates as intervocalic consonants) was analysed in this study. This represented an average of 20 (range = 12 – 28) tokens across 7 NJ and 3 NI speakers. The listeners’ task was to decide whether the medial consonant was short/singleton or long/geminate and indicate their choice using response categories appropriate for their linguistic background. Specifically, the NJ listeners and the NNJ learners were given response categories with a geminate symbol clearly marked in Japanese scripts whereas the NI listeners were given response categories labelled “Singola (Single)” and “Doppia (Double)”. The listeners made their responses by clicking on the response categories on the computer monitor with a mouse. Each listener was tested individually in a session lasting between 30 and 40 minutes. The presentation of the stimuli and the collection of perception data were controlled by the UAB (University of Alabama at Birmingham) software (Smith, 1997). The listeners could take a break after each block if they wished. They heard the stimuli at a self-selected, comfortable level over high-quality headphones (Sennheiser 200PX-II) attached to a notebook computer. The listeners were allowed, but not encouraged, to replay the stimulus tokens multiple
times and were asked to guess if uncertain\(^2\). No feedback was given during the experiment. Once a choice was made, the listeners were unable to change their decision and the next token was presented automatically. The first three trials in each block were for practice and were not analysed.

3. Results

3.1. Overall between-group differences

Figure 1 shows the mean percentage of correct identification for the Japanese and Italian stimuli by the four groups of listeners (two control (NJ, NI) and two experimental (NNJ-OZ, NNJ-Korean) groups) who differ in their experience with consonant length. For the Japanese stimuli, the impact of four non-words was non-existent for all four groups. After removing the non-words, the results were 100% correct identification for NJ, 89% for NI, 89% for NNJ-OZ, and 83% for NNJ-Korean. For the Italian stimuli, the mean percentages of correct identification for 24 words and 30 non-words differed minimally for the four groups (97% vs 94% for NJ, 100% vs 98% for NI, 91% vs 88% for NNJ-OZ, 85% vs 86% for NNJ-Korean).

As expected, the NJ and NI groups were most accurate in their L1s (99% for both the Japanese and Italian listeners). The two NNJ learner groups resembled each other in their overall accuracy of perceiving not only Japanese (87% and 83% for NNJ-OZ and NNJ-Korean, respectively) but also Italian (82% and 90% for NNJ-OZ and NNJ-Korean, respectively) consonant length. However, as shown in Figure 1, they were less accurate in perceiving consonant length in both Japanese (by 12% and 16% for NNJ-OZ and NNJ-Korean, respectively) and Italian (by 17% and 9% for NNJ-OZ and NNJ-Korean, respectively) than the native control groups. This confirms the previous finding that

\(^2\) We would not exclude the possibility raised by an anonymous reviewer that some listeners’ replay may have caused an extraneous variable, although we do not consider this to be serious. In our view, allowing replays is more practical, as it is a natural part of speech communication and also helps to reduce listeners’ anxiety.
length contrasts present processing difficulty when length is not systematically used in the L1 for phonemic purposes (e.g. Han, 1992; Sonu et al., 2013).

In order to identify any between-group differences in listeners’ perception of the tokens containing short and long consonants, their identification scores (calculated as percentage correct) were analysed in a two-way repeated-measures ANOVA with Group (G: NJ, NI, NNJ-OZ, NNJ-Korean) as a between-subjects factor and Stimulus Language (S: Japanese, Italian) as a within-subjects factor. The main effect of Group and the two-way interaction between Group and Stimulus Language reached significance \[ G: F(3, 42) = 5.5, p < 0.01, G \times S: F(3, 42) = 8.4, p < 0.001 \], but not the main effect of Stimulus Language \[ F(1, 42) = 1.4, p = 0.25 \]. A follow-up one-way ANOVA showed that the simple main effect of Group was significant for both the Japanese \[ F(3, 62) = 7.0, p < 0.001 \] and Italian stimuli \[ F(3, 62) = 5.3, p < 0.01 \], as the native advantage over non-native groups is clearly observed in Figure 1. The two-way interaction reached significance, because the NJ and NNJ-OZ groups were more accurate in identifying consonant length in Japanese than in Italian (99% vs 95% for NJ, 87% vs 82% for NNJ-OZ) while the reverse was the case for the NI and NNJ-Korean groups (89% vs 99% for NI, 83% vs 90% for NNJ-Korean).

A larger bias for the L1 stimuli over the non-native stimuli for the NI group (99% vs 89%) than for the NJ group (99% vs 95%) shows that NJ are better at perceiving Italian length than NI are at perceiving Japanese length. This result suggests cross-linguistic phonetic differences in singleton/geminate consonants in Italian and Japanese are at play. It is notable that, based on one-way ANOVA with three (NI, NNJ-OZ, NNJ-Korean) groups of listeners, there was no statistically significant between-group difference in perceiving the Japanese consonant length \[ F(2, 33) = 0.93, \]
$p = 0.40$, suggesting that NI listeners were able to efficiently utilize their experience with L1 Italian length in processing the Japanese singleton and geminate consonants. A comparable one-way ANOVA for the Italian stimuli across three (NJ, NNJ-OZ, NNJ-Korean) non-native groups showed that NJ listeners were significantly more accurate than NNJ-OZ (but not NNJ-Korean) listeners [$F(2, 29) = 3.6, p < 0.05$] in perceiving the Italian consonant length. The two NNJ groups did not significantly differ from each other.

3.2. Comparison between the two non-native Japanese (NNJ) learner groups

A two-way repeated-measures ANOVA with Group (NNJ-OZ, NNJ-Korean) as a between-subjects factor and Stimulus Language (Japanese, Italian) as a within-subjects factor was run to explore differences between the two NNJ groups. Neither of the main effects of Group (G) or Stimulus Language (S) reached significance [G: $F(1, 20) = 0.1, p = 0.76$, S: $F(1, 20) = 0.09, p = 0.76$], but the two-way interaction did [G x S: $F(1, 20) = 7.1, p < 0.05$], reflecting the opposite pattern of results for the two groups as shown in Figure 1. NNJ-Korean listeners were better at perceiving Italian stimuli compared to Japanese stimuli, whereas NNJ-OZ listeners were better at perceiving Japanese compared to Italian stimuli. This finding may suggest that FL Japanese learning by NNJ-Korean listeners is not as robust and L1 phonological knowledge is more influential, though this is not the case with NNJ-OZ listeners$^3$.

3.3. Comparison of Japanese tokens differing in accent type

Table 4 shows the identification accuracy of consonant length for all four groups of listeners as a function of the pitch accent type (HL vs LH).

$^3$ We thank an anonymous reviewer for pointing out this interpretation.
The influence of accent type was obvious only for the NNJ-Korean learners, who identified tokens containing singletons more accurately when the accent type was LH (82%) than when it was HL (71%) \[F(1, 56) = 10.57, p < 0.01\]. In other words, they misperceived singletons as geminates more frequently when the accent type was HL than when it was LH. However, their identification accuracy differed minimally for two accent types when the stimuli contained geminates (92% for HL and 89% for LH). The differing influence of accent type can be clearly observed in Figure 2. Thus, they had a bias toward hearing geminates when the accent type was HL, whether the consonant was actually long or short. This is consistent with results reported in Minagawa and Kiritani (1996). In a study involving 312 Taiwanese NNJ learners in their 20 to 30s (from beginners to advanced level of proficiency), Hung (2012) also observed a higher rate of geminate perception for the HL than for the LH accent type. In the stimuli of LH type, longer closure duration was needed to reach the same percentage of geminate identification compared to the stimuli of HL type.

In the present study, the difference in identification accuracy for naturally produced tokens differing in the accent type was negligible for the other three groups of listeners.

3.4. Direction of misperception - Japanese

We are interested in determining whether intervocalic singletons were misperceived as geminates or whether geminates were misperceived as singletons. The direction of misperception was expressed as the percentage of target singleton or geminate tokens erroneously perceived as the other
category in the forced-choice identification task. Figure 3 shows the mean percentage of singletons misperceived as geminates and geminates misperceived as singletons for the Japanese stimuli. As expected, the NJ listeners made the fewest misidentifications in both directions. The NNJ-Korean learners substantially differed from the other three groups of listeners by misperceiving singletons as geminates much more frequently than misperceiving geminates as singletons (24% vs 10%).

**Figure 3 about here**

Two-way repeated-measures ANOVA with Group (G: NJ, NI, NNJ-OZ, NNJ-Korean) as a between-subjects factor and Direction of Misperception (D: singleton as geminate, geminate as singleton) as a within-subjects factor showed a significant main effect of Group and the two-way interaction [G: \(F(3, 42) = 5.3, p < 0.01\), G x D: \(F(3, 42) = 7.2, p < 0.001\)], but not the main effect of Direction of Misperception [\(F(1, 42) = 1.4, p = 0.24\)]. A follow-up one-way ANOVA testing the simple main effect of Group was significant for both singletons misperceived as geminates [\(F(3, 62) = 8.1, p < 0.001\)] and for geminates misperceived as singletons [\(F(3, 62) = 3.3, p < 0.05\)], as the NJ listeners clearly outperformed the non-native listeners. A follow-up one-way ANOVA testing the simple main effect of Direction of Misperception reached significance only for the NNJ-Korean [\(F(1, 42) = 19.6, p < 0.001\)] as is clearly seen in Figure 3. There is little doubt that the NNJ-Korean learners had greater trouble with singletons than with geminates and this is consistent with the results reported in previous studies (Min, 2007; Minagawa & Kiritani, 1996). This may suggest that the NNJ-Korean learners’ representation of Japanese consonant length is asymmetrical and the representation of [-long] is fuzzier than that of [+long] (following Ramírez & Simonet, in press). The former may include both longer and shorter consonants while the latter may include more clearly specified long consonants.
3.5. Direction of misperception - Italian

Figure 4 shows the mean percentage of singletons misperceived as geminates and geminates misperceived as singletons for the Italian stimuli. As expected, the NI listeners made the smallest number of misidentifications for both directions. The pattern of results for the Italian stimuli clearly differ from that for the Japanese stimuli for the NNJ-Korean learners. While they had greater trouble with singletons than with geminates when they heard the Japanese stimuli (24% vs 10%), they had greater trouble with geminates than with singletons when they heard the Italian stimuli (17% vs 4%).

The listeners’ misidentification scores were analysed in a two-way repeated-measures ANOVA with Group (G: NJ, NI, NNJ-OZ, NNJ-Korean) as a between-subjects factor and Direction of Misperception (D: singleton as geminate, geminate as singleton) as a within-subjects factor to examine if there were between-group differences in the listeners’ direction of misperception of the Italian consonant length. Only the main effect of Group reached significance [G: F(3, 42) = 7.0, p < 0.001, D: F(1, 42) = 1.3, p = 0.26, G x D: F(3, 42) = 1.2, p = 0.32]. Of relevance to this study, the two NNJ learner groups did not differ from each other in the extent to which they misidentified geminates as singletons (18% and 17% for NNJ-OZ and NNJ-Korean, respectively). However, the NNJ-OZ learners (18%) more frequently misidentified singletons as geminates than did the NNJ-Korean (4%).

The NNJ-Korean learners had greater trouble with geminates than with singletons. Post hoc t-tests (with Bonferroni correction) indicated that the effect of direction of misperception reached significance [t(9) = -2.9, p < 0.05] for this group. On the other hand, the NNJ-OZ learners, for
whom misperception was bi-directional, resembled the NJ listeners in this aspect (albeit with
greater frequency of misperception) and qualitatively differed from the NNJ-Korean learners in
their perception of Italian consonant length.

4. Discussion

This study examined the perception of Japanese and Italian consonant length by four groups of
listeners differing in their linguistic backgrounds: the two control groups consisting of NJ and NI
speakers and the two experimental groups consisting of NNJ-OZ and NNJ-Korean learners. The
primary purpose was to assess how the NNJ learners perceive consonant length in FL Japanese and
in Italian (a language unfamiliar to them that uses consonant length contrastively). The perceptual
accuracy of these NNJ learners was compared to that of control NJ and NI listeners.

First of all, our results show that the NJ and NI listeners had a clear advantage over non-native
listeners in their L1 consonant length perception. As for the perception of unfamiliar, non-native
length contrasts, the NJ listeners identified Italian consonant length significantly more accurately
(95%) than did the NNJ-OZ (82%) (but not NNJ-Korean (90%)) learners. As for the non-native
perception of Japanese consonant length, there was no significant difference between the NI
listeners (89%) and the two groups of NNJ learners (87% for NNJ-OZ and 83% for NNJ-Korean,
respectively), suggesting that the NI listeners’ L1 experience was as beneficial as the NNJ learners’
FL Japanese learning experience.4 Thus, we demonstrated that experience with L1 consonant length
categories (as in Italian) might be more helpful than harmful when listeners process consonant
length in an unknown language.

In terms of how NNJ-OZ and NNJ-Korean learners may differ from each other in perceiving
consonant length in Japanese and Italian, we did observe different patterns of results for the two

4 An anonymous reviewer offered an alternative interpretation which is that the NNJ groups’
compatible perception level with the NI group has resulted from the NNJ’s learning effects.
groups. One of them was the differing effect of pitch accent type (HL vs LH) in the Japanese stimuli which only affected the NNJ-Korean group. Regardless of the length category, the NNJ-Korean learners tended to hear more geminates than singletons when the accent type was HL. This replicates findings previously reported (Minagawa & Kiritani, 1996) and deserves further investigation. More intriguingly, while the NNJ-Korean learners misperceived singletons as geminates more frequently than misperceiving geminates as singletons in Japanese (Figure 3), this direction of misperception was reversed when they listened to the Italian stimuli (Figure 4). It thus appears that the NNJ-Korean learners do not equate singletons and geminates in the two languages. Their representations of [+long] may be asymmetrical but in the opposite direction according to the stimulus language. On the other hand, the NNJ-OZ learners’ direction of misperception did not depend on the stimulus languages. Compared to the NNJ-Korean learners who hardly misidentified the Italian singletons (4%), NNJ-OZ learners more frequently misidentified the Italian singletons as geminates (18%). To put it another way, NNJ-OZ learners’ representations of [+long] may be more symmetrical than NNJ-Korean learners’ and they may equate singletons and geminates in the two languages to a greater extent than do the NNJ-Korean learners when applying the feature [+long].

Taken together, these findings suggest that some NNJ learners, depending on their L1, may categorize length in Japanese and Italian differently rather than uniformly applying the general concept of [+long] across different languages with contrastive consonant length. We would not have gained this insight if we had only examined NNJ learners’ consonant length perception in FL Japanese.

Despite their ongoing FL Japanese learning experience, the NNJ learners were not indistinguishable from the native listeners in identifying the Japanese consonant length contrasts. Interestingly, they did not differ from the NI listeners with no experience in Japanese, with each group performing more poorly compared to the NJ listeners. This finding reconfirms the notion that phonemic length
poses a challenge to non-native learners from diverse backgrounds (Kubozono, 2013), even when
speakers of a language such as Korean have access to geminate-like phonetic lengthening.

As stated by Kawahara (2015, p. 59), “the phonetic implementation patterns of singleton-geminate
contrasts are language-specific, the only universal rule being that geminates are longer than
singletons (Ham, 2001; Ridouane, 2010)”. As previously noted, various studies report that vowels
preceding geminates are longer in Japanese than vowels preceding singletons (Han, 1992; Idemaru
& Guion, 2008), but the opposite is the case in Italian where the duration of the vowel is known to
be shorter before geminate than before singleton consonants (Hajek et al., 2007). Thus, the
complementarity of adjacent short-long sounds varies from one language to another, which means
that this knowledge is not innate and must be learned. It is likely that such stark cross-linguistic
phonetic differences have a measurable influence on the perception of the length contrasts.

In fact, our results show that NNJ/Koreans were better at perceiving the consonant length contrast
in Italian rather than in Japanese. This could be related to their experience with preceding vowel
duration as a cue to the tense/lax consonant contrast in L1 Korean, in a fashion similar to the
long/short contrast in Italian. On the other hand, if this link to predictable vowel duration holds, it
remains unclear why the NNJ-Korean listeners showed significantly greater difficulty in the
perception of geminates compared to singletons in Italian. Further investigation of this point is
needed.

It has been reported that “phonetic extra-long voiceless obstruents are frequent” in Japanese (Vance,
2008). As mentioned in the Introduction, geminate /tː/ may be particularly prevalent and noticeable
in Japanese as a highly productive past tense marker (/ita/ stayed, was/were vs /itːa/ said or went,

/ʃita/ did vs /ʃitːa/ knew/found out, etc). It may be the case that some NNJ learners may
overgeneralize this knowledge and misperceive singletons as geminates in Japanese especially in
cases of uncertainty. However, the same NNJ learners may not necessarily apply this strategy when they make length judgements on the unfamiliar Italian stimuli. Another question then arises as to whether and how frequency of occurrence affects ease of perceptual learning.

We were also interested in exploring whether learning Japanese can facilitate the perception of the length contrast in other languages. Our results show that the FL Japanese learning experience was possibly facilitative and transferred positively to NNJ learners’ perception of Italian consonant length, because the NNJ learners correctly identified the unfamiliar Italian length category more than 82% of the time. Correct identification such as this is highly unlikely for naïve listeners, although future research is still required to test this hypothesis. To this extent, our findings suggest that FL (and possibly L2) learning experience rather than simply L1 or phonetic similarity may play a role in cross-language transfer effects.

Our study has laid the groundwork for future research. This includes 1) testing a larger number of NNJ learners, tightly controlling their levels of Japanese proficiency, to better understand when and how NNJ learners acquire the skills to accurately perceive length contrasts in Japanese; and 2) testing NI learners of FL Japanese on the one hand and NJ learners of FL Italian on the other hand on how they perceive consonant length in each other’s language. Would NI learners of FL Japanese have an added advantage over NNJ-OZ and NNJ-Korean learners and demonstrate more native-like performance? Or would they still differ from the NJ norm? It would also be illuminating to test NJ and NI listeners’ perception of consonant length in yet another language (e.g. Arabic, Finnish) to compare whether they differ in their sensitivity to length in general. The findings would broaden our understanding of the role of prior linguistic experience in cross-language speech perception.

Although this study only included stops and affricates, in future work we would systematically examine the effect of consonant type (i.e. manner, place) by including a wider range of consonants. Minimal pairs contrasting in singleton/geminate consonants appear to be more prevalent in Japanese
than in Italian (Vance, 2008) and Italian allows for gemination of a greater number of consonants than does Japanese. As this asymmetry may affect listeners’ cross-language perception, it would be desirable to ensure a balance of tokens between the two stimulus languages.

We would also use more controlled stimuli as in Kubozono et al. (2011) (i.e. identical duration but varying in pitch patterns) to understand better to what extent accent types may or may not play a role in the perception of consonant length by NNJ as well as NJ listeners. This study is also limited to speech materials in citation-form, so it is not clear if the NNJ learners respond to continuous speech or speech at different speaking rates in a manner comparable to NJ (and NI) listeners.

Finally, while neither the PAM(L2) nor SLM predicts perception difficulties for speakers whose L1 uses phonemic length as they process notionally similar length categories in unfamiliar languages, the extent of cross-linguistic (dis)similarity needs to be established empirically in order to assess the limits of the validity of these models. Both Japanese and Italian have only two length categories, short and long, while there are undoubtedly a greater number of segmental (i.e. vowel, consonant) categories in most languages. Length contrasts may also be more susceptible to speaking rate (Hirata, 2004; Hirata & Tsukada, 2009) than segmental contrasts.

Although it is unclear how NNJ learners assimilate long and short consonants in Japanese and Italian to their existing sound categories, a comparison between the two groups of listeners from the same L1 background but differing in Japanese language experience would demonstrate if and to what extent the known learning difficulty with length contrasts can be overcome and the phonetic learning can extend to another language. The extent of FL (or L2) to L3 phonological transfer may also be related to the strength of NNJ learners’ cognitive representations of Japanese length categories acquired in adulthood. If they are accurately and firmly established, perceptual patterns may be highly native-like and resemble those of control groups. To verify this possibility and to better understand the source of potential cross-linguistic transfer effects, more clearly defined NNJ
groups are needed in future research. By including these NNJ learners at different levels of proficiency, we may gain a valuable insight into whether learning FL Japanese has any influence on the processing of their other sound systems, both familiar and unfamiliar.

5. Conclusions

The results obtained in this study suggest that the two groups of NNJ learners from different L1 backgrounds have the ability to process consonant length contrasts accurately (greater than 80%) not only in FL Japanese but also in an unknown language, Italian. However, the analyses presented here showed that the NNJ learners still did not reach the native level of accuracy in identifying Japanese consonant length, reconfirming earlier research that phonemic length is difficult to acquire. Furthermore, an analysis of differences in the overall accuracy of perception as well as in the direction of misperception for the two length categories raises the possibility that some NNJ learners, according to L1 background, do not uniformly equate consonant length in known and unknown languages and may use different processes (e.g. phonetic vs phonological and/or differing L1 constraints) in categorizing length in the two languages.

Acknowledgements

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References


Table 1. Japanese words and non-words used.

<table>
<thead>
<tr>
<th>Consonant</th>
<th>Without Geminate (Underlying 2-mora, 2-syllable)</th>
<th>With Geminate (Underlying 3-mora, 2-syllable)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High-Low (HL)</td>
<td>Low-High (LH)</td>
</tr>
<tr>
<td>/t/</td>
<td>/kate/ win</td>
<td>/buta/ pig</td>
</tr>
<tr>
<td>/kato/</td>
<td>/kato/ transition</td>
<td>/heta/ unskilled</td>
</tr>
<tr>
<td>/soto/</td>
<td>/soto/ outside</td>
<td>/mito/ place name</td>
</tr>
<tr>
<td>/mate/</td>
<td>/mate/ wait</td>
<td>/nita/ boiled</td>
</tr>
<tr>
<td>/moto/</td>
<td>/moto/ original</td>
<td>/oto/ sound</td>
</tr>
<tr>
<td>/sate/</td>
<td>/sate/ well, then</td>
<td>/uta/ song</td>
</tr>
<tr>
<td>/tata/</td>
<td>/tata/ many</td>
<td>/wata/ cotton</td>
</tr>
<tr>
<td>/tate/</td>
<td>/tate/ stand, shield</td>
<td>/tate/ standing</td>
</tr>
<tr>
<td>/tete/</td>
<td>/tete/ (non-word)</td>
<td>/tate/ shining</td>
</tr>
<tr>
<td>/toto/</td>
<td>/toto/ (non-word)</td>
<td>/toto/ quickly</td>
</tr>
<tr>
<td>/ute/</td>
<td>/ute/ shoot</td>
<td></td>
</tr>
<tr>
<td>/k/</td>
<td>/aka/ red</td>
<td>/ake/ open</td>
</tr>
<tr>
<td></td>
<td>/buka/ subordinate</td>
<td>/fuki/ butterbur</td>
</tr>
<tr>
<td></td>
<td>/kaka/ spurious fruit</td>
<td>/haka/ grave</td>
</tr>
<tr>
<td></td>
<td>/kako/ past</td>
<td>/hako/ box</td>
</tr>
<tr>
<td></td>
<td>/koko/ individual</td>
<td>/kake/ bet</td>
</tr>
<tr>
<td></td>
<td>/keke/ (non-word)</td>
<td>/saka/ slope</td>
</tr>
<tr>
<td></td>
<td>/neko/ cat</td>
<td>/jike/ rough sea</td>
</tr>
<tr>
<td></td>
<td>/nika/ lesson two</td>
<td></td>
</tr>
<tr>
<td></td>
<td>/ika/ below</td>
<td></td>
</tr>
<tr>
<td></td>
<td>/rika/ science</td>
<td></td>
</tr>
<tr>
<td></td>
<td>/jake/ desperate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>/joka/ leisure</td>
<td></td>
</tr>
<tr>
<td>/tf/</td>
<td>/itfi/ one</td>
<td></td>
</tr>
<tr>
<td></td>
<td>/fitfi/ seven</td>
<td></td>
</tr>
</tbody>
</table>
Table 2. Italian words and non-words used.

<table>
<thead>
<tr>
<th>Without geminate (underlying 2-syllable)</th>
<th>With geminate (underlying 2-syllable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>/p/ /kapa/ head (regional, sub-standard form)</td>
<td>/kap:a/ mantle</td>
</tr>
<tr>
<td>/papa/ pope</td>
<td>/pap:a/ mush</td>
</tr>
<tr>
<td>/pipi/ you smoke a pipe</td>
<td>/pip:i/ (non-word)</td>
</tr>
<tr>
<td>/popo/ (non-word)</td>
<td>/pop:o/ (non-word)</td>
</tr>
<tr>
<td>/pupu/ (non-word)</td>
<td>/pup:u/ (non-word)</td>
</tr>
<tr>
<td>/t/ /fato/ fate</td>
<td>/fato/ fact</td>
</tr>
<tr>
<td>/note/ note (plural)</td>
<td>/note/ night</td>
</tr>
<tr>
<td>/sata/ (non-word)</td>
<td>/sata/ (non-word)</td>
</tr>
<tr>
<td>/sete/ thirst</td>
<td>/sete/ seven</td>
</tr>
<tr>
<td>/siti/ sites (plural)</td>
<td>/siti/ (non-word)</td>
</tr>
<tr>
<td>/satu/ (non-word)</td>
<td>/satu/ (non-word)</td>
</tr>
<tr>
<td>/tata/ nanny</td>
<td>/tata/ (non-word)</td>
</tr>
<tr>
<td>/titi/ (non-word)</td>
<td>/titi/ (non-word)</td>
</tr>
<tr>
<td>/toto/ all (ant.)</td>
<td>/toto/ (non-word)</td>
</tr>
<tr>
<td>/tutu/ (non-word)</td>
<td>/tutu/ (non-word)</td>
</tr>
<tr>
<td>/k/ /eko/ echo</td>
<td>/eko/ here</td>
</tr>
<tr>
<td>/keke/ (non-word)</td>
<td>/keke/ gay male (plural)</td>
</tr>
<tr>
<td>/kiki/ (non-word)</td>
<td>/kiki/ grain, grape (plural)</td>
</tr>
<tr>
<td>/koko/ (non-word)</td>
<td>/koko/ coconut</td>
</tr>
<tr>
<td>/kuku/ (non-word)</td>
<td>/kuku/ (non-word)</td>
</tr>
<tr>
<td>/b/ /bobo/ (non-word)</td>
<td>/bobo/ (non-word)</td>
</tr>
<tr>
<td>/d/ /dede/ (non-word)</td>
<td>/dede/ (non-word)</td>
</tr>
<tr>
<td>/dodo/ dodo</td>
<td>/dodo/ (non-word)</td>
</tr>
<tr>
<td>/g/ /gaga/ (non-word)</td>
<td>/gaga/ (non-word)</td>
</tr>
<tr>
<td>/gogo/ (non-word)</td>
<td>/gogo/ (non-word)</td>
</tr>
<tr>
<td>/lego/ I tie</td>
<td>/lego/ I read</td>
</tr>
<tr>
<td>/dʒ/ /adʒo/ ease</td>
<td>/adʒo/ premium</td>
</tr>
</tbody>
</table>
Table 3. Listeners in this study and their L1 characteristics with respect to length contrasts.

<table>
<thead>
<tr>
<th>Group</th>
<th>L1</th>
<th>Number</th>
<th>Experience with consonant length contrasts in L1</th>
</tr>
</thead>
<tbody>
<tr>
<td>NJ</td>
<td>Japanese</td>
<td>5f, 5m</td>
<td>Yes</td>
</tr>
<tr>
<td>NI</td>
<td>Italian</td>
<td>9f, 5m</td>
<td>Yes</td>
</tr>
<tr>
<td>NNJ-OZ</td>
<td>Australian English</td>
<td>9f, 3m</td>
<td>No</td>
</tr>
<tr>
<td>NNJ-Korean</td>
<td>Korean</td>
<td>6f, 4m</td>
<td>No</td>
</tr>
</tbody>
</table>
Table 4. Mean percent correct identification (%) of Japanese stimuli as a function of accent pattern by four groups of listeners. The standard deviations are in parentheses.

|                | Without geminate
|----------------|--------------------------------------------------|
|                | (underlying 2-mora, 2-syllable) | With geminate
|                |                                  | (underlying 3-mora, 2-syllable) |
|                | HL               | LH               | HL               | LH               |
| NJ              | 100 (0)          | 100 (0)          | 100 (0)          | 99 (2)           |
| NI              | 90 (14)          | 89 (9)           | 80 (22)          | 82 (20)          |
| NNJ-OZ          | 92 (12)          | 90 (10)          | 87 (17)          | 90 (16)          |
| NNJ-Korean      | 71 (20)          | 82 (15)          | 92 (7)           | 89 (9)           |
Figure 1: Percentage of correct identification of Japanese (white bars) and Italian (shaded bars) stimuli by four groups of listeners. The error bars indicate ± one standard error of the mean.
Figure 2: Percentage of correct identification of Japanese stimuli in HL and LH accent by NNJ-Korean learners: tokens with singleton (white bars) and tokens with geminate (shaded bars). The error bars indicate ±one standard error of the mean.
Figure 3: Percentage of misperception according to direction from singleton to geminate (white bars) and geminate to singleton (shaded bars) by four groups of listeners (Japanese stimuli). The error bars indicate ±one standard error of the mean.

Japanese Stimuli

- singleton → geminate
- geminate → singleton

Listener group:

- NJ
- NI
- NNJ-OZ
- NNJ-Korean
Figure 4: Percentage of misperception according to direction from singleton to geminate (white bars) and geminate to singleton (shaded bars) by four groups of listeners (Italian stimuli). The error bars indicate ±one standard error of the mean.