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Speech perception and loanword adaptations: the case of copy-vowel epenthesis

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Abstract

Japanese allows for almost no consonants in syllable codas. In loanwords, illegal codas are transformed into onsets by means of vowel epenthesis. The default epenthetic vowel in loanwords is [ɯ], and previous work has shown that this [ɯ]-epenthesis reflects Japanese listeners' perception of illegal coda consonants. Here, we focus on one of the non-default cases: following coda [ç] and [x] the epenthetic vowel is a copy of the preceding vowel. Using an identification and a discrimination task, we provide evidence for the perceptual origin of this copy vowel phenomenon: After [ç] and [x], Japanese listeners perceive more often an epenthetic copy vowel than the default vowel [ɯ], whereas after [k] it is the reverse.

Index Terms: speech perception, loanword adaptations, vowel copy, epenthesis

1. Introduction

The relation between speech perception and loanword adaptations has been the topic of vivid theoretical debate [for reviews, see 1,2] and of much experimental research [e.g. 3-8]. One type of adaptation that has drawn attention in particular is that of vowel epenthesis, applied to make loanwords conform to the phonotactics of the borrowing language. Japanese, for instance, allows almost no coda consonants and is well known for turning these into onset consonants in loanwords by means of vowel epenthesis. The default epenthetic vowel is [ɯ], and there is robust evidence that this adaptation reflects the perception of an illusory [ɯ] by Japanese listeners [9,10]. Yet, in certain phonological contexts, Japanese uses another epenthetic vowel in loanwords. Here, we focus on the phenomenon of copy-vowel epenthesis, attested in loanwords from languages that contain a coda [ç] or [x], such as German, Dutch and Czech. Examples are shown in (1) [see also 11].

(1) Ich-Roman [içroman] → [iç:iromaɴ] 'I-novel' [German]
Bach [bax] → [bah:a] [German]
Van Gogh [xox] → [faɴgoh:o][1] [Dutch]

Note that [ç] and [x] themselves are generally adapted as [h:]; after [i], though, [ç] is not modified because the copy vowel licenses the presence of this consonant in Japanese, which is an allophone of /h/.

[1] The adaptation of the onset [x] as [g] is surprising. Perhaps the name was borrowed via English, in which *Gogh* is sometimes pronounced as [gɒx].

Japanese not only lacks a productive epenthesis process, it also has no vowel harmony, making copy vowel epenthesis in loanword adaptations particularly intriguing. A previous perception study with Japanese listeners focused on coda [h], and found that, compared to coda [k], it is often perceived with a copy vowel rather than with the default epenthetic vowel [ɯ] [12]. While that article was not concerned with the relation between speech perception and loanword adaptations, it did mention the presence of a meaningful correspondence of the perception results with the Japanese adaptation pattern illustrated in (1). A proper examination of the perceptual origin of copy-vowel epenthesis, however, should focus on the perception of the German and Dutch consonants in the input to loanword adaptation, i.e. coda [ç] and [x], rather than on the perception of coda [h]. This is especially important since [h] strongly coarticulates with surrounding vowels [13], which previously was argued to account for the perceptual copy vowel effect in the context of this consonant [12]. By contrast, vowel coarticulation is not as strong in [ç] and [x]. Thus, in this article we focus on Japanese listeners' perception of coda [ç] and [x].

We use both an identification and a discrimination task with German nonce word stimuli to test the hypothesis that Japanese listeners tend to perceive a copy vowel rather than the default epenthetic vowel [ɯ] after the consonants [ç] and [x]. In German, [ç] and [x] have complementary distributions, such that [ç] occurs after front vowels and [x] after back vowels; our stimuli reflect this distribution. In both tasks, we compare the perception of coda [ç] and [x] to that of a control consonant, i.e. coda [k]. In the identification task, participants are asked to indicate if they hear a vowel and if so, which one, in the middle of [V_1CV_1]-stimuli whose first consonant is either one of [ç] and [x] or [k]. We expect overall high rates of responses with an epenthetic vowel, and among these, more copy vowel responses for items with [ç] and [x] (e.g., [eçpe], [oxpo]) and more default [ɯ] responses for items with [k] (e.g., [akpa]). In the discrimination task, participants are asked to discriminate between the same [V_1CV_1]- and corresponding [V_1CV_1pV_1]-stimuli in an ABX paradigm. We expect worse discrimination of the pairs with [ç] and [x] (e.g. [içpi]-[içipi], [axpa]-[axapa]) than of those with [k] (e.g. [ekpe]-[ekepe]), due to the fact that epenthesis with a copy vowel but not that with the default vowel [ɯ] increases the perceptual similarity between the items within the test pairs.

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2. Experiment

2.1. Participants

We recruited 45 native Japanese speakers, 19 men and 26 women, aged between 19 and 51 (mean: 29; SD: 7.65). Twenty-two of them lived and were tested in Tokyo, the remaining 23 in Paris.

2.2. Materials

We constructed a total of 20 di- and trisyllabic items; in half of them the crucial consonant was [ç] or [x], and in the other half it was [k]:

- [ç] / [x]: [içpi], [eçpe], [axpa], [oxpo], [uxpu]
  [içipi], [eçepe], [axapa], [oxopo], [uxupu]
- [k]: [ikpi], [ekpe], [akpa], [okpo], [ukpu]
  [ikipi], [ekepe], [akapa], [okopo], [ukupu]

Note that following German phonotactics, [ç] occurs in the context of [e] and [i] and [x] in the context of [a] and [o].

In addition, we constructed six trisyllabic items with [k] in the crucial position and a middle vowel different from the one in initial and final position, to be used for a training phase in the discrimination task. These training items were [akipa], [akopa], [ekape], [ekope], [okapo], [okipo].

None of the trisyllabic items turns into a real Japanese word when [u] is replaced by [ɯ], and [ç] or [x] by [h].

All items were recorded with initial stress by three native speakers of German, two women and one man.

2.3. Procedure

Participants were tested individually in a quiet booth and received instructions in English, written on a computer screen. The experimenter in Paris spoke English or French with the participants, the one in Tokyo spoke Japanese, a language in which she had a conversational level of proficiency. All participants carried out the identification task first, followed by the discrimination task. At the end, they filled in a language background questionnaire.

2.3.1. Identification

Participants were told that they would listen to invented words and that for each of them they had to indicate what they heard in the middle: no vowel, or one of [a,e,i,o,ɯ]. They replied by pressing one of six adjacent keys on a computer keyboard, which contained stickers displaying the response options.

All the stimuli of one of the female speakers (the same one for all participants) were presented seven times, for a total of 140 trials. The trisyllabic items served as fillers; the disyllabic items were test items for one half (items with [ç] or [x]) and control items for the other half (items with [k]). A one-second silence separated trials from one another. The experiment lasted about 15 minutes.

2.3.2. Discrimination

Participants were told that they would listen to series of three invented words, with the last one being identical to either the first or the second one, and that for each series they had to indicate – by pressing one of two arrow keys (left/right) on a computer keyboard – whether they thought the last word was identical to the first or the second one.

There were 240 trials with an ISI of 500 ms. Half of the trials concerned items with one of [ç] and [x], the other half concerned items with [k]. In each trial, the first stimulus was produced by one of the female speakers, the second one by the other female speaker, and the third one by the male speaker. A one-second silence separated trials from one another, and participants could take a short break after ¼, ½, and ¾ of the trials.

Preceding the test trials, 10 training trials were presented on which participants received feedback as to their accuracy. In these training trials, both A and B were trisyllabic items that differed in their vowels. None of the items contained [ç] or [x], and the middle vowel was always different from the one in initial and final position. (E.g. [ekope]-[akipa]-[ekope], and [okapo]-[ekape]-[ekape].)

The experiment lasted about 30 minutes.

2.4. Results

All analyses were carried out in *R* [14] by means of logistic or linear mixed effects models (the former for the identification task and for accuracy in the discrimination task, the latter for response times in the discrimination task), using the *lme4* package [15] and the bobyqa optimizer [16] whenever necessary to reach convergence. Fixed factors were contrast-coded. Statistical significance was established by comparison between the full model and a model without the relevant factor, using likelihood-ratio testing [17].

2.4.1. Identification

Before analyzing the responses to the crucial disyllabic items, we verified performance on the trisyllabic filler items. One participant made 50% errors on these items; their data were excluded from further analyses.[2]

Turning next to the disyllabic items, the mean percentages of epenthetic responses were 44.9 (SE=7.42) for items with [ç] or [x] and 47.0 (SE=7.44) for items with [k]. A post-hoc assessment of the data revealed a large difference in the epenthesis rates after [ç] and [x]: [ç], appearing in the contexts of the front vowels [e] and [i], yielded on average 69.0% epenthesis (SE=6.90), and [x], appearing in the contexts of the back vowels [a] and [o], yielded on average 28.9% epenthesis (SE=6.76).[3] In our model for the analysis of the epenthesis rates we therefore included, in addition to the main effect for Consonant ([ç]/[x] vs. [k]), a main effect for Vowel Place (front vs. back) and the Consonant × Vowel Place interaction. We added a maximal random structure, hence with intercepts for Participant and Item and by-Participant slopes for Consonant, Vowel Place, and their interaction. The model revealed effects of Vowel Place (β=0.55, SE=0.19, z=2.91, $\chi^2(1)$=6.76, p<.01) and of Consonant × Vowel Place (β=-1.13, SE=0.18, z=-6.10,

[2] Many other participants had high error rates on the items with [u], which they tended to perceive as [o].

[3] We verified that the mean epenthesis rates to items with [k] did not show a similar difference according to vowel context: 40.6% (SE=7.33) in the context of [e] and [i] vs. 51.3 (SE=7.46) in the context of [a] and [o].

$\chi^2(1)=17.3, p<.0001$), but no effect of Consonant ($z<1$). Thus, participants experienced perceptual epenthesis more often on the items with front vowels (i.e., [e,i]) than on those with back vowels (i.e., [a,o]), and this difference was more prominent for items with [ç] or [x] than for those with [k].

Focusing on the trials with an epenthetic response, we next examined potential differences between default and copy vowel epenthesis. We excluded responses for [uxpu] and [ukpu], as the expected epenthetic vowel [ɯ] can be interpreted both as a copy vowel and as the default epenthetic vowel. Table 1 shows for all other items the number of epenthetic responses and the mean percentages of epenthesis with the default vowel [ɯ], a copy vowel, or another vowel.

Table 1: *Number of epenthetic responses (N), and mean percentages of different types of epenthetic responses; standard errors in parentheses.*

	N	Default	Copy	Other
[ç]-[x]	597	14.9% (5.3)	50.3% (7.5)	34.8% (7.1)
[k]	548	86.1% (5.2)	11.0% (4.7)	2.9% (2.5)

For items with [ç] or [x], the high percentage of responses with an epenthetic vowel that is neither the default vowel [ɯ] nor a copy vowel is due almost entirely (i.e., in 96% of cases) to the item [eçpe]. This item was perceived as [eçipe] in 91% of the trials; we hypothesize this to be due to one or both of the speaker's [e]'s being perceived as Japanese [i].[4] Hence, the real amount of copy vowel epenthesis after [ç] and [x] is probably underestimated by these data. In order to analyze the epenthetic responses, we therefore discarded [eçpe],[5] which left 378 trials in the test condition, of which 21.4% with default [ɯ]-epenthesis (SE=6.13), 76.2% with a copy vowel (SE=6.36), and 2.4% with another epenthetic vowel (SE=2.28).

Among the epenthetic responses with either the default or a copy vowel, we analyzed the proportion of copy vowel responses. Given that [içpi] yielded more copy vowel responses (i.e. 98.0%, SE=2.08) than [axpa] and [oxpo] (mean: 53.6%, SE=7.46), the model contained not only Consonant but also Vowel Place and its interaction with Consonant as fixed effects. As before, the random structure was maximal. The model revealed an effect of Consonant (β=-7.66, SE=1.90, z=-4.04, $\chi^2(1)=31.5$, $p<.0001$), and a Consonant × Vowel Place interaction (β=5.65, SE=1.96, z=2.88, $\chi^2(1)=10.7$, $p<.002$), but no effect of Vowel Place (β=-2.41, SE=1.90, z=-1.27, $\chi^2(1)=1.72$, $p>.1$). Thus, the amount of copy vowel responses was larger for items with [ç] or [x] than for those with [k], and this difference was more prominent for items with a front vowel than for those with a back vowel.

[4] Unfortunately, we know of no loanword with coda [ç] or [x] preceded by [e], and hence cannot rule out that such a sequence would be adapted by means of [i]-epenthesis as opposed to copy vowel epenthesis. However, in the trisyllabic items the percentage of [i]-responses to [eçepe] likewise stood out among the errors, lending credence to our hypothesis that the speaker's [e] is perceived as Japanese [i] in the context of [ç]. An open question remains whether this might be true for other German speakers, too.

[5] Keeping this item would lead to convergence issues, which is unsurprising given the small numbers of items overall and the deviant response pattern for [expe].

2.4.2. Discrimination

One participant (not the same one as the one excluded from the analyses of the identification task) performed below chance-level in both the test and control condition; their data were excluded from analyses. As before, we also excluded all trials with the vowel [u], as performance on these trials is uninformative with respect to the nature of the perceived epenthetic vowel, i.e. copy vowel or default [ɯ]. Finally, we excluded the response time (RT) data for two subjects whose RTs were more than 2.5 standard deviations above the mean.

Table 2 shows the mean accuracy rates and RTs for trials with [ç] or [x] (test) and those with [k] (control).

Table 2: *Mean accuracy rates and RTs, with standard errors.*

	Accuracy (%)	RT (ms)
[ç]-[x]	82.4 (5.6)	1318 (162)
[k]	92.5 (4.0)	1184 (135)

Similarly to what was found with the identification task, a post-hoc assessment revealed rather large differences in both the accuracy rates and the reaction times for [ç] and [x]: [ç], appearing in the contexts of the front vowels [e] and [i], yielded on average 74.8% correct responses (SE=6.55) and reaction times of 1425 msec (SE=170), while [x], appearing in the contexts of the back vowels [a] and [o], yielded on average 89.9% correct responses (SE=4.53) and reaction times of 1211 (SE=152). In addition to Consonant, we therefore again included Vowel Place and the Consonant × Vowel Place interaction in our models. For the accuracy data, the biggest random structure allowing for convergence contained an intercept for Participant and by-participant slopes for Consonant and Vowel group. For the (log-transformed) RT data, the random structure was kept maximal.

Both models revealed effects of Consonant (accuracy: β=0.69, SE=0.07, z=8.49, $\chi^2(1)=39.4$, $p<.0001$; RT: β=0.07, SE=0.01, z=5.49, $\chi^2(1)=14.1$, $p<.001$), Vowel Place (accuracy: β=1.06, SE=0.14, z=7.58, $\chi^2(1)=36.1$, $p<.0001$; RT: β=0.08, SE=0.02, z=4.70, $\chi^2(1)=11.3$, $p<.001$), as well their interaction (accuracy: β=0.20, SE=0.08, z=2.41, $\chi^2(1)=5.49$, $p<.02$; RT: β=0.06, SE=0.02, z=3.62, $\chi^2(1)=8.25$, $p<.005$). Thus, participants were both less accurate and slower on trials with [ç] or [x] compared to trials with [k], as well as on trials with front vowels compared to trials with back vowels; the interactions reflected the larger differences in accuracy rate and response time between trials with [ç] or [x] versus those with [k] in the context of front vowels.

Focusing on the condition with [ç] and [x], we examined the consistency of the results with those in the identification task. For this, we computed for each item except [eçpe] and for each of the 43 participants whose data were included in both tasks, the mean percentage of copy responses after [ç] or [x] in the identification task as well as the mean accuracy on the trials with [ç] or [x] of the discrimination task. We then built a model with mean discrimination accuracy as dependent variable and mean percentage copy responses as fixed factor, adding random intercepts for participant and item. The effect of the fixed factor was significant (β=-0.16, SE=0.04, z=-4.17, $\chi^2(1)=12.53$, $p<.001$). Thus, the results of the two tasks are indeed consistent: higher amounts of copy epenthesis in identification predict lower accuracy in discrimination.

2.5. Discussion

In the identification task, we presented items with a coda consonant and found more copy vowel responses when the consonant was [ç] or [x], and more default [ɯ] responses when it was [k]. In the discrimination task, we paired items with a coda consonant to correspondents with a copy vowel and found worse performance when the consonant was [ç] or [x] than when it was [k]. Both results are as predicted, and show that Japanese listeners tend to perceive a copy vowel rather than the default epenthetic vowel [ɯ] after the consonants [ç] and [x].

In addition, we found differences according to vowel context, which for the items with [ç] or [x] maps onto the difference between these two consonants. In identification, the amount of copy as opposed to default epenthesis was especially large in [içpi]. (Recall that analysis of [eçpe] was hampered by the fact that one or both [e]'s were likely perceived as [i]). Similarly, discrimination performance was worse in the context of front vowels; this held not only for trials with [ç] or [x], but to a lesser extent also for those with [k]. These data indicate, firstly, that copy vowel epenthesis is particularly prominent after [ç]. Japanese has borrowed only a few loanwords with a coda [ç] or [x], all of which showing an epenthetic copy vowel. In our original analysis plan we therefore had not included a distinction between [ç] and [x], or, extending towards items with [k], a distinction between front and back vowels. Secondly, concerning items with [k], worse discrimination of [ekpe]-[ekepe] and [ikpi]-[ikipi] suggests that default [ɯ]-epenthesis – which for these item pairs makes discrimination easy – is less prominent in the context of front vowels. This finding is not relevant for the question of copy vowel epenthesis, but it meshes well with results from a previous perception study on the effects of vowel coarticulation on the perception of the coda consonants [k] and [h]: It was shown that [i]- and – to a lesser extent – [e]-coarticulation yield fair amounts of [i]-epenthesis, especially following [h] [12]. Moreover, it is reflected in loanword adaptation, as [i]-epenthesis sometimes occurs in the presence of front vowels (e.g. [meki**i**ʃiko] 'Mexico').

Two previous studies on perceptual epenthesis in Japanese focused on default [ɯ]-epenthesis [9,18]. Both also contained identification and ABX tasks with naturally produced stimuli and – for ABX – multiple speakers. Overall performance in our experiments is relatively good compared to performance in these previous studies. That is, the mean percentage of epenthetic responses we observed in identification is between 15 and 25 percent points lower and the mean accuracy in the challenging condition with [ç] and [x] we observed in discrimination is between 18 and 27 percent points higher. From these differences we cannot conclude, however, that coda [ç] and [x] stand out as being easier to perceive by Japanese listeners. Indeed, in identification our participants performed better not only on items with [ç] and [x] but also on those with [k]. Alternatively, the difference might stem from a possible higher L2 proficiency in our participants.

We examined directly a possible effect of L2 proficiency on perceptual epenthesis post-hoc in a series of simple linear regressions, focusing on individual mean accuracy rates in the challenging condition with [ç] and [x] of the discrimination task. All participants had learned one or more foreign languages that allow for coda consonants (seven of them knew some German). We used the following predictors: lowest age of acquisition of such a language (range = 0-28 years, mean = 11 years, SD = 4.6; one missing datapoint), age of arrival and length of residence in a country where such a language is spoken (N=29; AoA (one missing datapoint): range = 0-34 years, mean = 21 years, SD = 9.1; LoR: range = 6 months - 16 years, mean = 4.7 years, SD = 4.5), current residency (Tokyo: N=22; Paris: N=22), and self-estimated proficiency (on a five-point scale) for the foreign language known best (range = 1-5, mean = 3.4, SD = 1.0). Only the latter predictor was significant (adjusted R^2=0.15, $F(1,42)$=8.52, Bonferroni-corrected p<.03), with higher estimated proficiency corresponding to higher accuracy, suggesting that foreign language learning can indeed reduce perceptual epenthesis in Japanese listeners.

3. Conclusion

The present study provides evidence for the perceptual origin of copy vowels in Japanese loanword adaptations: Japanese listeners tend to perceive a copy vowel rather than the default epenthetic vowel [ɯ] after the consonants [ç] and [x]. Given the relatively low amount of epenthesis overall and the correlation between accuracy and self-estimated proficiency in one or more languages with coda consonants, future research should examine in more detail the extent to which foreign language learning can reduce perceptual epenthesis, whether after coda [ç] and [x] or more generally after any coda consonant.

Similarly, it would be interesting to directly examine the link between perception and loanword adaptation using an on-line adaptation task, in which participants are presented auditorily with nonce words that they are asked to produce as borrowings within a Japanese sentence (see [19]). This is especially relevant for the case of copy vowel epenthesis, as nowadays Japanese hardly borrows words from languages with coda [ç] and [x] such as German. Thus, while in novel borrowings default [ɯ]-epenthesis is still widely attested, there is but little evidence that copy vowel epenthesis is presently an active repair strategy [11]. Carrying out an on-line adaptation task would also allow one to shed light on the potential difference between [ç] and [x] in light of this repair strategy.

Finally, copy vowel epenthesis in loanword adaptations is not restricted to Japanese. Particularly interesting are other languages with this phenomenon that - like Japanese - do not have a productive process of vowel harmony, such as Hawaiian [20], American Italian [21] and Korean [22]. Results from a first experimental study on Korean suggest that in that language too, copy vowel epenthesis – which applies across other consonants than [ç] and [x] – reflects perception. Future research, involving more languages, is necessary to examine possible limits of a perceptual account of copy vowel epenthesis in loanword adaptations, as well as the phonetic factors inducing the presence of illusory copy vowels during speech perception.

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