【Forum】

Japanese Geminate Perception in Nonsense Words Involving German [f] and [x]

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Abstract: Nonsense words involving German voiceless fricatives [f] or [x] (or [ç]) were used to test Japanese subjects' perception of gemination, and the friction durations were measured. Results showed that, similar to existing loanwords in Japanese, subjects were overall more likely to perceive gemination for stimuli involving [x] (or [ç]) than for those involving [f], despite the fact that no significant difference between the durations of these voiceless fricatives was found. In addition, the relationship between fricative environment (i.e. CV$\underline{C}$, CCV$\underline{C}$, CV$\underline{C}$ən, where $\underline{C}$ is the voiceless fricative) and rate of gemination was examined. Similar to existing loans, results indicated that fricatives were more likely in the environment CCV$\underline{C}$ than CV$\underline{C}$ to be adapted into Japanese as geminates. Opposite of the existing loanword trend, however, fricatives were less likely to be geminated if followed by a syllabic nasal (i.e. CV$\underline{C}$ vs. CV$\underline{C}$ən). Comparing friction duration across the different word environments, [f] and [x] (or [ç]) were found to have a shorter duration word-medially (CV$\underline{C}$ən) than word-finally (CV$\underline{C}$, CCV$\underline{C}$). Thus, a shorter difference in frication duration, controlled by word environment, was correlated with lower perception of gemination in the test words. Concerning the quality of the preceding short vowel (e.g. [l$\underline{a}$x] vs.[l$\underline{o}$x]), no influence on fricative geminate perception was observed.*

Key words: gemination, loanwords, German, voiceless fricatives

1. Introduction

While adaptation of foreign words into Japanese has been the focus of many studies, one issue that remains unclear is the problem of predicting when and why Japanese loanwords employ gemination (Q), or *sokuon*, to represent foreign

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consonant sounds. While a large proportion of established Japanese loanwords are of English origin, other source languages may also provide clues for why one word is borrowed into Japanese employing a single consonant while a similar word is adapted using a double consonant. Particularly in the case of voiceless fricatives, it has not been fully determined whether geminate perception depends on a property of Japanese phonology, a phonetic detail in the source language, or some combination of factors. In this study, I will use nonsense words involving German [f] and [x] (or [ç])[1] to attempt to contribute evidence for defining and solving this problem.

2. Previous Studies

There have been several studies that discuss principles concerning the likelihood of consonant gemination in Japanese loanwords, including differences based on the quality of the word-final consonant, the presence of a word-initial consonant cluster, and presence of a word-final syllabic sonorant.

Several scholars have shown how some word-final consonants more than others are likely to be adapted into Japanese as geminates. For example, within the voiceless fricative consonant group, it has been observed that source language [ʃ] is more likely than [s] to be geminated in Japanese (Ohye 1961; Maruta 2001; Kubuzono 2007), as shown in (1).

(1) bus → ba.su bush → buʃ.ʃu
mass → ma.su vs. cash → kyaʃ.ʃu
pass → pa.su push → puʃ.ʃu

This trend is statistically confirmed in Maruta (2001), where it was found in a loanword survey that 43/47 (91%) of [ʃ]-final words were borrowed with gemination, but in [s]-final words this rate was only 3/241 (1%).

Examining another set of voiceless fricatives with examples in (2), Ohye (1961) notes that source words ending in [f] are resistant to gemination in Japanese. Kubozono (2007), however, points out that those ending in [x] (or [ç]) are readily geminated.

(2) tough → ta.fu (J.S.) Bach → bah.ha
puff → pa.fu vs. Mach (number) → mah.ha
(Van) Gogh → goh.ho

In support of these examples, Maruta's (2001) survey also showed that words ending in [f] are geminated at a rate of only 3/23 (13%), a low value relative to the overall ratio of gemination observed in the total 972 survey words (63%). As the Maruta (2001) study surveyed English-origin loans, no [x]-final word statistics were included.

[1] /x/ is phonetically realized as the voiceless velar fricative [x] after /a/, /o/, /u/ but as the voiceless palatal fricative [ç] after /i/ and /e/ in German. Therefore it is implied, and sometimes stated, throughout this paper that this study groups the velar [x] and palatal [ç] fricatives together, comparing them in opposition to the labiodental fricative [f].

In addition to this factor of the word-final consonant type, another factor affecting the likelihood of gemination concerns whether the word-initial consonant is a singleton or a cluster of consonants. Ohye (1961) observed that the words *tough* and *staff* are treated differently with regard to gemination, as shown in (3), and Kubozono (2007) generalizes this asymmetry saying that voiceless fricatives and voiced stops are more likely to be geminated if an onset consists of a consonant cluster, with further examples in (4).

(3) tough → ta.fu vs. staff → su.taf.fu
(4) log → ro.gu vs. frog → fu.rog.gu
knob → no.bu snob → su.nob.bu

Also, from previous studies is the observation that word-final voiceless fricatives tend to become less resistant to gemination if followed by a syllabic sonorant in the source language, as noted in various works (Ohye 1961; Maruta 2001; Kubozono 2007), and shown in (5).

(5) less → re.su vs. lesson [lɛsən] → res.sun
tough → ta.fu waffle [wafəl] → waf.fu.ru
bus → ba.su hustle [hʌsəl] → has.su.ru

Investigating English-origin words ending in multiple consonants, Maruta (2001) provides several supporting statistics. It was found that words ending in [f] + syllabic r were adopted into Japanese in the geminate form in 6 of 13 tokens (46%). Recall that the Maruta (2001) survey also showed that words ending in [f] alone were geminated at a rate of only 3/23 (13%). Also, the few included words in this survey ending in [s] + syllabic r were found to employ the geminated fricative in 3 of 3 tokens (100%), with the rate of gemination for words ending in single [s] at only 3/241 (1%). Furthermore, with regard to other obstruents, Arai and Kawagoe (1996) show a higher gemination rate in words of type CV[p] followed by [-ɪn], [-ɪŋ], or [-ən] than in CV[p] appended by a non-nasal syllable such as [-ɪs], reinforcing the idea that the presence of a word-final nasal influences geminate perception.

These three main factors concerning the likelihood of consonant gemination in Japanese—the quality of the word-final consonant, the presence of a word-initial consonant cluster, and presence of a word-final syllabic sonorant—help to describe the problem, but a more fundamental reason as to why some loanwords are geminated and some are not has yet to be found. Is it a property of Japanese phonology, the influence of the source orthography, a phonetic detail in the source language, or perhaps some combination of these factors?

Concerning voiceless fricatives in particular (i.e. [s] vs. [ʃ]; [f] vs.[x]), Kubozono (2007) suggests that their asymmetric treatment in terms of loanword gemination is perhaps not based in Japanese phonology but rather may be due to a phonetic cue, fricative closure duration, in the source language,[2] pointing to the need for an

[2] As support for this idea, Kubozono (2007) points out the incongruity that [s] and [ʃ]

investigation of whether [ʃ] and [x] (or [ç]) have a longer duration than do [s] and [f] respectively. Previous work of Fujisaki and Sugito (1977) supports this idea as they submit that duration contrasts are of fundamental importance for geminate perception in Japanese words. They note that for voiceless fricatives in particular, it is the duration of the friction closure to which Japanese listeners are sensitive when distinguishing a singular versus a geminated sound.

3. Research Questions

In this study, I will use nonsense words to attempt to provide additional support for these cited observations of the asymmetric treatment of various voiceless fricatives (i.e. [s] vs. [ʃ]; [f] vs.[x]), and explore whether or not there is indeed a phonetic duration cue in the source language that helps to account for these differences. For this limited study only the German set [f] versus [x] (or [ç]) was investigated. The German language was employed for this study because, unlike English, it makes use of the voiceless velar [x] (and palatal [ç]), along with labiodental [f], making possible a comparison between these fricatives within the same source language. Specifically, the questions I wish to address in this study are the following:

(6) a. Do Japanese listeners perceive gemination in the test words more often with German [x] (or [ç]) than with [f]?
b. Does having an onset consisting of a consonant cluster (e.g. [flox] vs. [lox]) increase geminate perception as it does in some observed loanwords?
c. Does the presence of a word-final syllabic nasal (e.g. [lafən̩] vs. [laf]) make gemination of the fricative more likely as is the case with some known loanwords?
d. Does a difference in quality of the short vowel that precedes the fricative consonant affect rate of gemination? (e.g. [la̲x] vs.[lo̲x])
e. Is there a measurable difference in duration of German [f] versus [x] (or [ç]) in any of the environments CV$\underline{C}$, CCV$\underline{C}$, CV$\underline{C}$ən?
f. Does duration of fricative closure correlate with perception of gemination?

4. Method

Thirty German-type nonsense words were used in the survey.[3] This set included ten of each of the word types CV$\underline{C}$, CCV$\underline{C}$, and CV$\underline{C}$ən, with $\underline{C}$ representing

would show such predictably different gemination behavior despite the fact that when they are adapted into Japanese, these sounds both fall into the same sa-line of the Japanese sound chart (which includes [sa, ʃi, su, se, so]), suggesting a close association of [s] and [ʃ] in Japanese. Likewise, [f] and [x] (with [ç]) are similarly adapted into the Japanese ha-line which includes [ha, çi, ɸu, he, ho] (word-final [f] typically becomes [ɸu], word-final [x] is generally borrowed as [ha], [ɸu], or [ho], and [ç] as Japanese [çi] or [he]). While [s] versus [ʃ] and [f] versus [x] (or [ç]) show clear asymmetry in terms of loanword gemination, they are respectively treated similarly in terms of phonological categorization in Japanese.

[3] It happens that several of these words actually do have meaning in German, but for the

[f] or [x] (or [ç]). In addition, five different short German vowels were included: [a], [ɛ], [ɪ], [o], and [u]. Table 1 shows a complete listing and distribution of test words.

Table 1. Test words

CVC (10 words)	CCVC (10 words)	CVCən (10 words)	Total (30)
[laf, lɛf, lɪf, lof, luf]	[flaf, flɛf, flɪf, flof, fluf]	[lafən, lɛfən, lɪfən, lofən, lufən]	C=/f/ (15)
[lax, lɛç, lɪç, lox, lux]	[flax, flɛç, flɪç, flox, flux]	[laxən, lɛçən, lɪçən, loxən, luxən]	C=/x/ (15)

A native speaker of German pronounced and recorded these words in random order using Praat software (Boersma and Weenink, 2007), with each word spoken two times in succession. This recording was played with the use of headphones to 12 native speakers of Japanese ranging in age from 21 to 63, with a median age of 33.

The Japanese participants were asked to mark the katakana transcription that best matched the German pronunciation of the test word they heard. One katakana option showed a single fricative and the other showed a geminated fricative transcription. For example, given the German pronunciation of *floch* [flox], two katakana answer options were provided: fu.ro.ho and fu.roh.ho. In addition, participants could mark "Other" and write their own katakana transcription if they thought the pronunciation fit neither of the two given options, as shown in (7).

(7) A. フロホ B. フロッホ C. その他（スロッホ）
A. fu.ro.ho B. fu.roh.ho C. Other (su.roh.ho)

5. Results

Frequency of choosing the geminated transcription was tallied from the Japanese participant answer sheets. In the cases that a participant marked "Other" and wrote an original response as in (7), this response was tallied simply noting the presence or absence of gemination.

5.1. Geminate perception for [f] versus [x] (or [ç]) words

With regard to question (6a), it can be seen in Table 2 that subjects chose the geminated transcription more times overall for [x] (or [ç]) than for [f] words.[4]

purpose of this study they can be considered nonsense words as they were very likely unknown to the perception survey participants. Only one of the twelve participants had experience studying German, with one year of foreign language exposure at the university level.

[4] It should be noted here that the denominators in Table 2 percentage calculations should all ideally be 60 (5 words in each word type (e.g. CVf=[laf, lɛf, lɪf, lof, luf]) x 12 subjects x 1 answer per subject). However, some subject responses could not be tallied for presence or absence of gemination, as in such cases when someone would choose "other" on the survey but fail to write any original transcription. Therefore, these participant responses were simply taken out of the calculation.

Table 2. Total percentage and frequency of gemination observed for all test word groups

Test Word Type \ Fricative	C=[f]	C=[x] (or [ç])
CVC	**32%** (19/59) (19:40:1)	**67%** (40/60) (40:20:0)
CCVC	**63%** (38/60) (38:22:0)	**75%** (42/56) (42:14:4)
CVCən	**9%** (5/55) (5:50:5)	**17%** (9/54) (9:45:6)

Numbers in table are as follows from top to bottom:
1) Percentage of gemination
2) Token count for the percentage calculation (+Q tokens) / (total of all +Q and –Q tokens counted)
3) Token count indicates (+Q:–Q:Not counted). This "Not counted" category represents those whose responses could not be tallied as either +Q or –Q.

This is particularly clear for the word type CVC. Test words of type CVf were geminated in 32% of the survey tokens, but CVx words showed twice the frequency of gemination at 67%. For the CCVC word category, [x] (together with [ç]) at 75% showed a higher rate of gemination than [f] at 63%. Also CVCən words produced a similar trend with 17% versus 9% occurrence of gemination for [x] (with [ç]) and [f] respectively.

5.2. Geminate perception comparing word types CVC, CCVC and CVCən

Addressing question (6b), the presence of a word-initial consonant cluster seems to increase perception of gemination (i.e. CVC vs. CCVC) in the cases of both [f] and [x] (or [ç]) words. As shown in Table 2, the total percentage of gemination for CVf is 32%, but this rate doubles to 63% for CCVf words. CCVx words also show a slightly higher geminate percentage (75%) than CVx words (67%).

As a final reference to Table 2, let us turn to question (6c), of whether having a word-final syllabic nasal affects gemination (i.e. CVC vs. CVCən). It was found that regarding both [f] and [x] (with [ç]), the rate of gemination in CVCən words is actually lower than in CVC words. CVf word gemination of 32% decreases to 9% for CVfən. Similarly, the 67% gemination rate for CVx notably drops to 17% for the CVxən word type.

5.3. Geminate perception based on the preceding short vowel

With regard to question (6d), concerning the effects of the quality of the short vowel preceding the fricative, no striking trend was observed for any one of [a], [ɛ],

[ɪ], [o] or [u], as shown in Table 3.

Table 3. Gemination results for [f] and [x] grouped by the preceding vowel

Vowel / Fricative and word type	[a]	[ɛ]	[ɪ]	[o]	[u]
All [f] word types (CV<u>C</u>, CCV<u>C</u>, CV<u>C</u>ən)	**26%** (9/34) (9:25:2)	**26%** (9/35) (9:26:1)	**37%** (13/35) (13:22:1)	**49%** (17/35) (17:18:1)	**40%** (14/35) (14:21:1)
All [x] (or [ç]) word types (CV<u>C</u>, CCV<u>C</u>, CV<u>C</u>ən)	**65%** (22/34) (22:12:2)	**40%** (14/35) (14:21:1)	**53%** (18/34) (18:16:2)	**56%** (19/34) (19:15:2)	**53%** (17/32) (17:15:4)
Total	**46%** (31/68) (31:37:4)	**33%** (23/70) (23:47:2)	**45%** (31/69) (31:38:3)	**52%** (36/69) (36:33:3)	**46%** (31/67) (31:36:5)

Durations of vowels (msec) by item are given in Appendix Tables 5 and 6
(For percent and frequency value explanations, see notes accompanying Table 2)

For example, [f] type words involving the short vowel [a] (i.e. [laf], [flaf], [lafən]) showed a relatively low percentage (26%) of gemination compared to the rate in other vowels of this row (range of 26–49%). However, no similar trend can be seen for [x] words involving [a]. In fact the opposite is true, with the group of [lax, flax, flaxən] showing 65% gemination compared to the lower range of 40–56% in other vowels. Also noting the bottom row of totals which includes both [f] and [x] (or [ç]) words, while [ɛ] shows a slightly lower gemination rate at 33%, the percentages for the other vowels is close to 50%, showing no particular tendency to enhance or impair geminate perception.

5.4. Friction closure duration measurements for [f] and [x]

To answer question (6e), the durations of German [f] and [x] (or [ç]) were measured in the environments CV<u>C</u>, CCV<u>C</u>, CV<u>C</u>en. For each German-type test word, Praat software (Boersma and Weenink 2007) was used to measure the duration of fricative closure, as shown in Figure 1 for the word [lɛf]. Since each word was spoken two times in succession, the average duration of the two tokens was calculated for each test word.[5]

[5] The difference between the 2 measured tokens averaged 14 msec for words involving [f], and 12 msec for words with [x] (or [ç]).

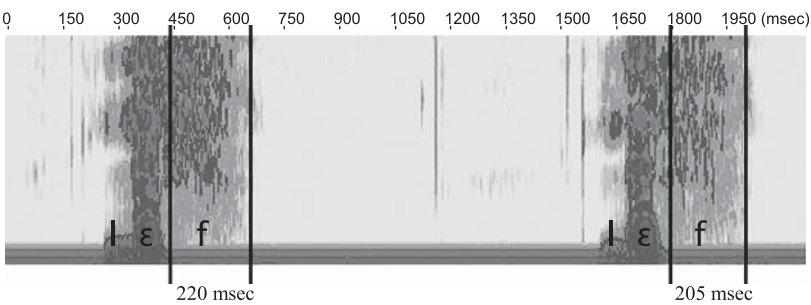

Figure 1. Spectrogram and fricative measurements of test word [lɛf]

As shown in Table 4, for both word types CVC and CCVC, [f] and [x] (likewise with [ç]) showed the same average friction duration of 220 milliseconds. Also for the CVCən word type, the durations of [f] and [x] (or [ç]) are nearly equal, with [f] in CVfən at 120 milliseconds and [x] (or [ç]) in CVCən showing a duration of 100 milliseconds.

Table 4. Average duration (msec) of German fricative [f] versus [x] (with [ç])

Word type \ Fricative	[f]	[x] (or [ç])
CVC	220	220
CCVC	220	220
CVCən	120	100

(A complete list of fricative duration values by token is given in Appendix Tables 5 and 6)

In sum, comparing [f] versus [x] (or [ç]), duration values are remarkably similar in each of the measured word environments. However, comparing across word types, the fricative measurements in CVCən yield a value of only about half the duration of either CVC or CCVC word types. This shows that word-medial fricatives have shorter durations than their word-final counterparts and implies that fricative location may be an important factor for perception of gemination in these test words, as will be presented in the next section.

5.5. Correlation of geminate perception and fricative duration

Concerning the final research issue (6f) of whether the duration of fricative closure correlates in any way with perception of gemination, several observations can be made, referencing Figures 2 and 3.

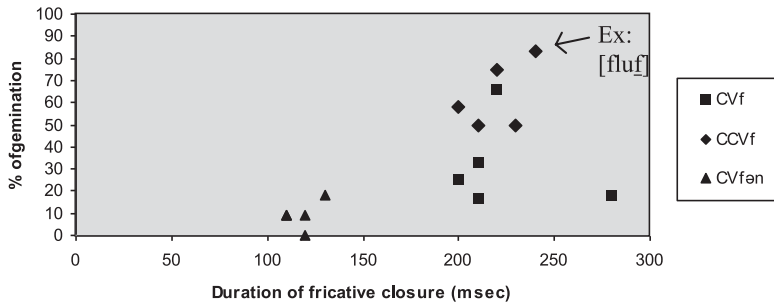

Figure 2. Percentage of perceived gemination as a function of fricative [f] duration
(Pearson correlation coefficient = 0.64)

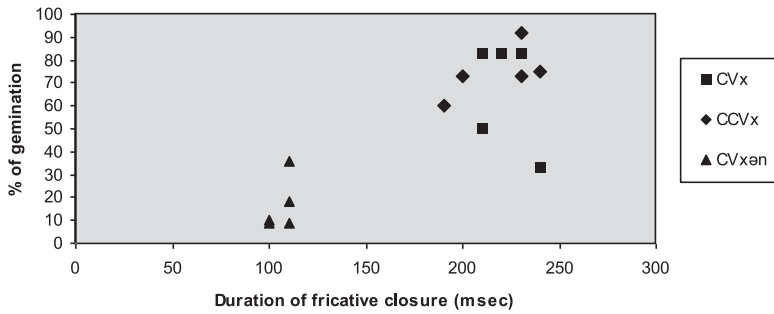

Figure 3. Percentage of perceived gemination as a function of fricative [x] (or [ç]) duration
(Pearson correlation coefficient = 0.84)

The data in Figures 2 and 3 for [f] and [x] (or [ç]) respectively were plotted using all three word types: CVC, CCVC, and CVCən. Each point in the figure represents the sum result of all participant responses for a given test word. For example, in Figure 2, the fricative duration of the final [f] in [fluf̲] is 240 milliseconds, and 10 of 12 subjects employed gemination to transcribe this word, a resultant gemination rate of 83%. Both Figures 2 and 3 produced a direct (while rough) linear relationship, with Pearson correlation coefficient at 0.64 for [f] data and 0.84 for [x] (or [ç]) data. In sum, for the cases of both fricative [f] and [x] (or [ç]), it can be seen that as the fricative duration—which is controlled by the word type—increases, the likelihood that the word will be perceived with consonant gemination also increases.

6. Discussion and Conclusion

The results of this study point to several generalizations. One is that the German voiceless velar fricative [x] (or palatal fricative [ç]) is more likely to be adapted into Japanese as a geminate than is the voiceless labiodental fricative [f], as was

shown in all the tested environments of CVC̲, CCVC̲, and CVC̲ən. This difference between [x] (or [ç]) and [f] is similar to the asymmetry of the English-origin fricative pair [ʃ] and [s] and seems to support the idea that there is a split with regard to voiceless fricatives in terms of Japanese loanword treatment—one group (including [x] (with [ç]) and [ʃ] may be readily geminated while the other group (including [f] and [s]) is resistant to gemination.

Also, in this perception survey subjects were only provided with the sound stimuli without any German orthography cues and yet showed the same basic adaptation patterns as seen in existing loanwords. This suggests that orthography does not exert any significant effect on the presence or absence of gemination for words involving [f] and [x] (or [ç]).

In addition, similar to observations with established loanwords by Ohye (1961) and Kubozono (2007), the current study showed that the presence of an onset consonant cluster (CVC vs. CCVC) increased gemination rate for word-final [f] and [x] (or [ç]) in the test words, supporting that this tendency of gemination may be widely observable across source languages for voiceless fricatives borrowed into Japanese loans.

While there are similarities in behavior between these German-type nonsense words and the largely English-origin established loanwords, there is also a notable difference: the influence of the presence of a word-final syllabic nasal on geminate perception. In established loanwords, having a word-final syllabic sonorant seems to increase likelihood of gemination of the preceding segment (Ohye 1961, Arai and Kawagoe 1996, Maruta 2001, Kubozono 2007). However, this trend is reversed in the current survey of test words as the presence of a syllabic nasal significantly reduced geminate perception for both [f] and [x] (or [ç]) test items. Perhaps the German syllabic nasal and English syllabic nasal have key acoustic differences that may account for this inconsistency.

Concerning the friction measurements in test words, no support was found for the hypothesis that a difference in duration is the reason that word-final [x] (with [ç]) is more readily perceived as a geminate than [f]. On the average, these sounds were uniformly found to be 220 milliseconds in duration word-finally and 100–120 milliseconds word-medially; therefore, the phonetic cue of frication duration does not seem to account for the difference in gemination rates for words involving [f] versus [x] (or [ç]). This is not to say that fricative duration was found to be an irrelevant factor for geminate perception in this study. While comparing duration values for [f] versus [x] (and [ç]) produced no significant value differences, comparing fricative closure duration word-finally (CVC̲, CCVC̲) versus word-medially (CVC̲ən) produced notable results, as shown in Figure 2 and 3 data plots. Japanese subjects did indeed seem to be sensitive to fricative duration, showing a tendency to perceive gemination more frequently—regardless of whether the fricative was [f] or [x] (or [ç])—in word types with a longer friction sound (i.e. CVC̲, CCVC̲), and at a correspondingly lower rate with the shorter word-medial fricative in CVC̲ən words.

Previous study observations of asymmetric behavior of [s] versus [ʃ] and [f]

versus [x] in established loanwords were supported in these test results of geminate perception. Also, comparing geminate perception rates across word types CV$\underline{C}$, CCV$\underline{C}$, and CV$\underline{C}$ən revealed both similarities and differences with tendencies of established loans. In addition, measurements of fricative durations across the three word environments and the correlation of these values to perception of gemination support the view that Japanese listeners are sensitive to fricative duration differences. That is to say, German [f] and [x] (with [ç]) are shorter in CVCən than in other environments and Japanese subjects were correspondingly more likely to rate these utterances as lacking gemination. At the same time, comparing German [f] versus [x] (with [ç]) showed no significant fricative closure duration difference and yet Japanese participants consistently identified [x] (or [ç]) as a geminate more frequently than [f]. More participants, survey items, and statistical analyses are undoubtedly needed to support these results and address remaining questions, but these issues will be left to more comprehensive future research.

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Appendix: Data by item

Table 5. Geminate perception and duration (msec) values for words involving fricative [f]

Word type \ Vowel		[a]	[ɛ]	[ɪ]	[o]	[u]	Total
CVf	%Q	**18%** (2/11) (2:9:1)	**17%** (2/12) (2:10:0)	**33%** (4/12) (4:8:0)	**66%** (8/12) (8:4:0)	**25%** (3/12) (3:9:0)	**32%** (19/59) (19:40:1)
	durations (msec)	f=280 a=110	f=210 ɛ=90	f=210 ɪ=70	f=220 o=100	f=200 u=90	f=220 vowel=90
CCVf	%Q	**50%** (6/12) (6:6:0)	**50%** (6/12) (6:6:0)	**58%** (7/12) (7:5:0)	**75%** (9/12) (9:3:0)	**83%** (10/12) (10:2:0)	**63%** (38/60) (38:22:0)
	durations (msec)	f=230 a=90	f=210 ɛ=90	f=200 ɪ=90	f=220 o=90	f=240 u=90	f=220 vowel=90
CVfən	%Q	**9%** (1/11) (1:10:1)	**9%,** (1/11) (1:10:1)	**18%** (2/11) (2:9:1)	**0%** (0/11) (0:11:1)	**9%** (1/11) (1:10:1)	**9%** (5/55) (5:50:5)
	durations (msec)	f=120 a=90	f=110 ɛ=80	f=130 ɪ=70	f=120 o=80	f=110 u=80	f=120 vowel=80

Numbers in table are as follows from top to bottom:
1) Percentage of gemination
2) Token count for the percentage calculation (+Q tokens) / (total of all +Q and –Q tokens counted)
3) Token count indicates (+Q:–Q:Not counted). This "Not counted" category represents those whose responses could not be tallied as either +Q or –Q.

Table 6. Geminate perception and duration (msec) for words involving fricative [x] (or [ç])

Word type \ Vowel		[a]	[ɛ]	[ɪ]	[o]	[u]	Total
CVx	%Q	**83%** (10/12) (10:2:0)	**33%** (4/12) (4:8:0)	**50%** (6/12) (6:6:0)	**83%** (10/12) (10:2:0)	**83%** (10/12) (10:2:0)	**67%** (40/60) (40:20:0)
	durations (msec)	x=210 a=100	ç=240 ɛ=100	ç=210 ɪ=90	x=220 o=90	x=230 u=70	/x/=220 vowel=90
CCVx	%Q	**73%** (8/11) (8:3:1)	**75%** (9/12) (9:3:0)	**92%** (11/12) (11:1:0)	**73%** (8/11) (8:3:1)	**60%** (6/10) (6:4:2)	**75%** (42/56) (42:14:4)
	durations (msec)	x=200 a=100	ç=240 ɛ=90	ç=230 ɪ=90	x=230 o=130	x=190 u=80	/x/=220 vowel=100
CVxən	%Q	**36%** (4/11) (4:7:1)	**9%** (1/11) (1:10:1)	**10%** (1/10) (1:9:2)	**9%** (1/11) (1:10:1)	**18%** (2/11) (2:9:1)	**17%** (9/54) (9:45:6)
	durations (msec)	x=110 a=80	ç=110 ɛ=80	ç=100 ɪ=80	x=100 o=100	x=110 u=70	/x/=100 vowel=80

(For percent, ratio, and other numerical value explanations, see notes accompanying Table 5)

【要旨】

無意味語における促音の知覚:ドイツ語の[f]と[x]の場合

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ドイツ語の [f] または [x] を含む無意味語を用いて日本語母語話者を対象に知覚実験を行い，摩擦の持続時間を測定した。[f] と [x] の間に持続時間の差が見られなかったが，日本語に実在する借用語に見られるものと同様に，[x] をもつ語の方が [f] をもつ語より促音挿入が起こりやすいことがわかった。さらに CV$\underline{C}$, CCV$\underline{C}$, CV$\underline{C}$ən（$\underline{C}$ は無声摩擦音のものである）の語型と促音化率の相関関係について実在語に見られる傾向と比較して論じる。