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【Forum】

A Corpus-Based Study of Geminate Devoicing in Japanese: The Role of the OCP and External Factors

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Abstract: Nishimura (2003, 2006) pointed out that in Japanese loanwords, voiced obstruent geminates can optionally devoice when they co-occur with another voiced obstruent (e.g. /doggu/ → [dokku] 'dog'). This devoicing pattern has been analyzed within a number of theoretical frameworks, and has thereby contributed to address several theoretical issues. The pattern, moreover, has been studied in several experimental, judgment-based studies. However, there are only a few studies on actual production data. Furthermore, all of the previous studies have generally assumed that the devoicing pattern under question is a sociolinguistically monolithic phenomenon. This paper addresses these two issues. By studying the Corpus of Spontaneous Japanese (Kokuritsu-Kokugo-Kenkyuujo 2008), we first confirm the previous claim that the OCP makes devoicing of geminates more likely in actual production data. Moreover, the results also reveal that many external, sociolinguistic factors affect the applicability of devoicing. The overall results thus contribute to the deeper understanding of the phenomenon by revealing various hitherto unnoticed factors that affect the applicability of devoicing.*

Key words: geminate, devoicing, the OCP, the CSJ, sociolinguistic factors

1. Introduction

Nishimura (2003, 2006) points out that in Japanese loanwords, voiced obstruent geminates can optionally devoice when they co-occur with another voiced obstruent, as exemplified by the data in (1). He further points out that this devoicing is due to a restriction against two voiced obstruents, a restriction which can be formalized as the OCP (voice) (Itô and Mester 1986, 2003), also known as Lyman's Law (Lyman 1894; Vance 2007). In other words, geminates do not devoice unless

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they occur with another voiced obstruent; i.e. unless they violate the OCP, as shown in (2). Moreover, Nishimura (2003, 2006) points out that devoicing is also impossible in OCP-violating singletons, as in (3).

(1) OCP-violating geminates can optionally devoice.
   a. be**dd**o → be**tt**o 'bed'
   b. ba**gg**u → ba**kk**u 'bag'
   c. bi**gg**u → bi**kk**u 'big'

(2) Non-OCP-violating geminates do not devoice.
   a. suno**bb**u → *suno**pp**u 'snob'
   b. he**dd**o → *he**tt**o 'head'
   c. re**gg**u → *re**kk**u 'leg'

(3) Singletons do not devoice, even when they violate the OCP.
   a. gi**b**u → *gi**p**u 'give'
   b. da**g**u → *da**k**u 'Doug'
   c. ba**g**u → *ba**k**u 'bug'

This paradigm, illustrated in (1)–(3), has been analyzed using various theoretical mechanisms: e.g. local conjunction (McCarthy 2008: 219–220; Nishimura 2003, 2006); phonetically-based phonology (Kawahara 2006, 2008; Steriade 2004); the theory of markedness and contrast (Rice 2006); Harmonic Phonology (Farris-Trimble 2008: 22–28; Pater 2009, to appear); Noisy Harmonic Phonology (Coetzee and Kawahara 2013; Coetzee and Pater 2011); and Maximum Entropy Grammar (Coetzee and Pater 2011).[1] This devoicing phenomenon is also discussed to address the issue of how loanword phonology and native phonology are related to one another (Crawford 2009; Itô and Mester 2008; Tateishi 2002). In summary, this pattern has contributed to many recent debates in phonological theory (see Kawahara 2011a and Kawahara 2012a for more extensive reviews, the former in English and the latter in Japanese).

Moreover, the Japanese loanword devoicing pattern has been studied in a number of naturalness judgment experiments (Kawahara 2011a, 2011b, 2012b, 2013b), partly because the pattern has played a non-trivial role in the recent phonological literature, and therefore its empirical foundations needed to be confirmed. In these studies, naive native speakers of Japanese judged the naturalness of devoicing in various contexts, including (1)–(3). The results generally corroborate the intuition-based data in (1)–(3) in that native Japanese speakers find the devoicing of OCP-violating geminates most natural. However, all of these studies also found that devoicing of non-OCP-violating geminates, as in (2), is judged to be not completely unnatural, despite the intuition by Nishimura (2003, 2006) and Kawahara (2006) to the contrary.

[1] Space limitation does not permit us to go into the details of these theoretical analyses. Kawahara (2012a) and Kawahara (2013a) present a summary of most of these analyses (the former in Japanese and the latter in English).

As much as this pattern has been studied from a variety of perspectives, both theoretical and experimental, there is one aspect of this phenomenon that needs to be studied more extensively. That is to study the data of actual production patterns: most of the theoretical analyses are based on the intuitions of Nishimura (2003, 2006) and Kawahara (2006). Although some experimental work more or less confirmed the intuitions (Kawahara 2011a, 2011b, 2012b, 2013b), they do not nevertheless answer the question of whether devoicing happens in actual production or not, and if so, how. Nishimura (2003, 2006), in the appendices to his papers, reports some analyses of the devoicing patterns using the Corpus of Spontaneous Japanese (the CSJ, see below), and shows the effect of the OCP on devoicing. The first aim of this study is to replicate this result with an updated version of the CSJ.[2]

Another question arises from our interests in the sociolinguistic aspects of devoicing pattern. The theoretical and experimental studies reviewed above assume that devoicing is sociolinguistically monolithic, abstracting away from external (extra-linguistic, sociolinguistic) factors.[3] A corpus-based study may show that this assumption may be too simplistic. We address these questions by using the Corpus of Spontaneous Japanese (Kokuritsu-Kokugo-Kenkyuujo 2008; Maekawa et al. 2000; Maekawa 2003, 2004; Sano and Hibiya 2012).[4]

To summarize the current questions:

(4) a. Do geminates devoice when they violate the OCP in the actual production patterns?
b. Can geminates ever devoice without violating the OCP?
c. The previous work has assumed that this devoicing pattern is sociolinguistically monolithic. Is this assumption true?

This study focused on how voiced geminates—but not voiced singletons—behave, because previous judgment studies (Kawahara 2011a, 2011b, 2012b, 2013b) show that devoicing is judged to be more likely for geminates than for singletons, and that devoicing of singletons is judged to be very unnatural. We therefore leave the study of singletons as a topic for future study.

[2] Two notes are in order. First, Nishimura (2003) used the monitor (trial) version, and Nishimura (2006) used the first version (p.c. Kohei Nishimura, Aug. 2012).

Second, we have also investigated the effects of some linguistic factors that are related to the OCP, but we report those results in a companion paper (Kawahara and Sano 2013), and the current paper focuses on external factors. We report linguistic and external factors in two separate papers for the sake of exposition, but in doing so, we also follow the claim that linguistic factors and external factors do not interact (Labov 1982; Sankoff and Labov 1979; Weiner and Labov 1983).

[3] One exception is the effect of lexical usage frequencies on the naturalness judgment of devoicing, investigated by Kawahara (2011a) and modeled by Coetzee and Kawahara (2013). The effect of lexical usage frequencies on actual production patterns in the CSJ is reported in Kawahara and Sano (2013).

[4] For other studies using the CSJ in a similar spirit, see for example, Sano (2008, 2011, 2012). See also http://www.ninjal.ac.jp/csj/.

To provide a brief preview of the results, we first confirm that devoicing is more likely when geminates violate the OCP, replicating Nishimura (2003, 2006); however, devoicing does nevertheless occur even when geminates do not violate the OCP, albeit only infrequently. We also find that some external factors affect the applicability of geminate devoicing in non-trivial ways. Moreover, the ways in which external factors affect the likelihood of devoicing are compatible with the previous observations on patterns of sociolinguistic variation and change.

The rest of this paper is structured as follows: Section 2 presents a detailed description of our data collection method. Section 3 looks at the effect of the OCP and other sociolinguistic factors on devoicing. Section 4 presents a multiple logistic regression analysis with all the factors included in one model. The final section offers brief concluding remarks.

2. Method

To investigate whether and how the OCP and external factors affect the devoicing of geminates in Japanese loanwords in actual production, we conducted an exhaustive search of the Corpus of Spontaneous Japanese, version 2 (the CSJ) (Kokuritsu-Kokugo-Kenkyuujo 2008; Maekawa 2003, 2004; Maekawa et al. 2000). This large-scale corpus is based on 662 hours of speech with 7.5 million words, produced by a total of 1,417 speakers. In addition to its large size, rich annotation system, and ease of searchability, another important characteristic of this database, which is particularly relevant for the purpose of our study, is that it provides both underlying forms and surface forms in terms of hatsuonkei ("pronounced forms"). This system allows us to retrieve a set of words with particular phonological characteristics based on underlying forms and study how the words are actually pronounced using the phonetic transcription provided.

We first extracted words with underlying voiced geminate obstruents from the CSJ (N=1,666), and then excluded tokens in which the voiced geminates underwent some changes other than devoicing, such as degemination and complete deletion, since our focus was on devoicing. This elimination process resulted in 1,617 data points (i.e. 97% of the data remained; see Sano 2013 for details). Among those, 464 tokens showed devoicing (28.7%). We then tested how the OCP and various sociolinguistic factors affect the probability of devoicing. We extracted all the tokens that fit each condition (=*n*), and counted how many of them are devoiced (=*m*). We then calculated the percentages of devoicing over *n* (i.e. 100 * (*m*/*n*)). The OCP is defined as containing another voiced obstruent within six preceding or following moras;[5] we deployed sociolinguistic factors that are encoded in the CSJ.

[5] It turned out that most of the OCP-induced devoicing was caused by a trigger in adjacent moras, but we included non-local triggers as well in this study. In Kawahara and Sano (2013), we study in detail how linguistic factors affect the applicability of devoicing. Those linguistic factors include the locality between the trigger and the geminate, and the effect of the number of triggers, among others. Our current study focuses on external factors (and the general role of the OCP).

3. Results and Discussion

3.1. Devoicing and the OCP

Figure 1 illustrates the likelihood of devoicing of voiced geminates for the OCP-violating condition (e.g. [beddo]) and the non-OCP-violating condition (e.g. [heddo]). We observe that devoicing happens about 40% of the time in the OCP-violating condition (=438/1099), while devoicing happens only about 5% of the time in the non-OCP violating condition (=26/518) ($\chi^2(1) = 207.1$, $p < .001$).

This production-based data supports the intuitions of Nishimura (2003, 2006) and Kawahara (2006) that the OCP is a crucial factor in inducing devoicing (Kawahara and Sano 2013). The current results replicate the corpus studies reported in the appendices of Nishimura (2003, 2006) which used older versions of the CSJ; the current results also support the experimental results that the OCP makes devoicing of geminates more natural (Kawahara 2011a, 2011b, 2012b, 2013b).

It is not the case, however, that devoicing is completely impossible for non-OCP-violating geminates, as it does happen about 5% of the time. The fact that context-free devoicing of geminates is not impossible (though unlikely) may be the basis of the judgment patterns in Kawahara (2011a, 2011b, 2012b, 2013b).

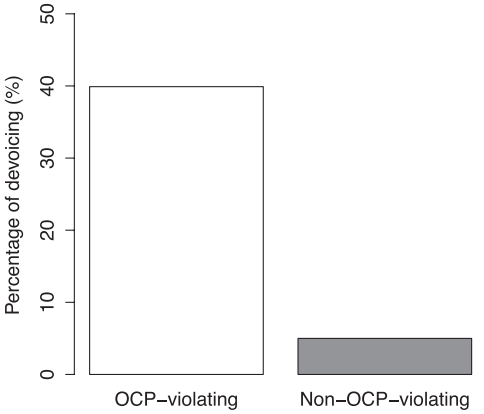

Figure 1. The effect of OCP on devoicing

3.2. Age

Now we move on to the effect of sociolinguistic factors. The following discussion treats the faithful rendition (voiced version) as "norm" and "standard", and the devoiced rendition as "innovative" and "vernacular", as the faithful forms are older forms, reflecting the pronunciations of the donor languages more accurately. For example, a standard dictionary like Shimmura (2008) lists [doggu], not [dokku], as its lexical entry for the word 'dog'.[6]

[6] As an anonymous reviewer points out, for some forms at least, the devoiced renditions

Figure 2 shows the correlation between the speakers' birth years (categorized with 10 year increments)[7] and the likelihood of devoicing, together with Table 1, which provides the actual numbers of occurrences of devoicing. We observe a positive correlation between these two parameters in that younger speakers tend to devoice more often. Although the correlation did not reach statistical significance due to the small N ($N = 6$; $p = .18$), the non-parametric correlation measure ρ is reasonably high (=.66).[8] This observation is compatible with the general sociolinguistic observation that younger speakers tend to prefer innovative, vernacular pronunciations (Chambers 2002; Labov 1966, 1972, 1994, 2001b; Romaine 1984).

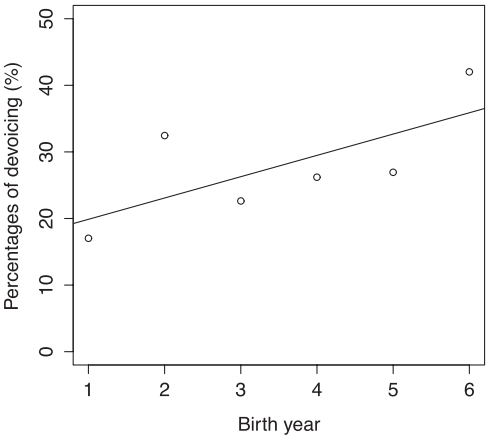

Figure 2. The effect of birth years by 10 year increments (Category 1=1925–1934; 2=1935–44; 3=1945–54; 4=1955–64; 5=1965–74; 6=1975–84)

Table 1. The effect of birth years by 10 year increments (actual numbers)

	1	2	3	4	5	6
n	8/47	37/114	43/190	115/439	153/568	108/257
%	17%	32.5%	22.6%	26.2%	26.9%	42%

may be the "standard", but we cannot think of a good way to objectively determine which lexical items take the voiced rendition as the standard form and which forms take the voiceless rendition as the standard form. Our method at least provides an objective way to define what is standard. This assumption should of course be examined more carefully in future studies.

[7] The CSJ provides birth-years in 5-year increments. Since there were some gaps when we analyzed the data with 5-year increments, we used 10-year increments.

[8] Since the birth-year categories are an ordered pseudo-numerical variable, and since we are interested in the linear correlation between birth years and devoicing percentages, we deployed a non-parametric correlation analysis.

3.3. Gender

Figure 3 shows the effect of gender on devoicing, which shows that female speakers show devoicing more often (207/503=41.2%) than male speakers (257/1114=23.1%) ($\chi^2(1) = 54.5$, $p < .001$). This observation makes sense from a diachronic point of view—female speakers are known to initiate sound changes (Eckert 1989; Labov 1966, 1990; Trudgill 1972; Romaine 2003). To the extent that a variable phonological pattern can be considered as an on-going diachronic change (Weinreich et al. 1968), the results are thus compatible with the previous observation in the sociolinguistic literature.[9]

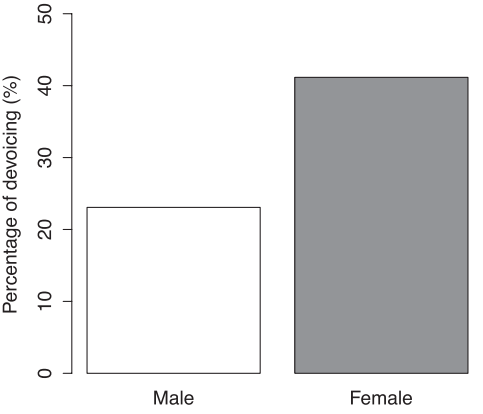

Figure 3. The effect of gender

3.4. Speech style: APS vs. SPS

Figure 4 shows the effect of speech style on the probability of devoicing. APS (for "Academic Presentation Speech") is live recording of academic presentations in various academic societies, whereas SPS (for "Simulated Public Speaking") consists of general speeches by laypeople on everyday topics. APS is characterized by a formal speaking style, whereas SPS is characterized by a casual and informal style.[10]

[9] An anonymous reviewer pointed out that female speakers may prefer to use prestigious forms (Trudgill 1972), and to the extent that voiced forms are more prestigious (because they are "standard"), the pattern in Figure 3 could be a contradiction to this claim. However, as Labov (1990: 215) argues, "[i]n change from below, women are most often the innovators." The devoicing case at hand is "in change from below" because it is a systematic change, which is more often observed in casual speech style (Section 3.4). We therefore believe that this gender effect is not an anomaly, if we follow Labov's observation about the effect of gender on sound changes.

[10] We have also checked the effect of the 5-point scale rating on speech formality provided by the CSJ. The analysis revealed a similar effect. Since the results are similar, we only report the APS/SPS distinction.

The result of this analysis shows that devoicing is more likely in SPS (297/714=41.6%) than in APS (155/872=17.8%) ($\chi^2(1) = 108.2, p < .001$), and this trend makes sense given the previous observation that speakers tend to use standard forms more often in formal speech styles than in casual speech styles (Labov 1963, 1966, 2001a).

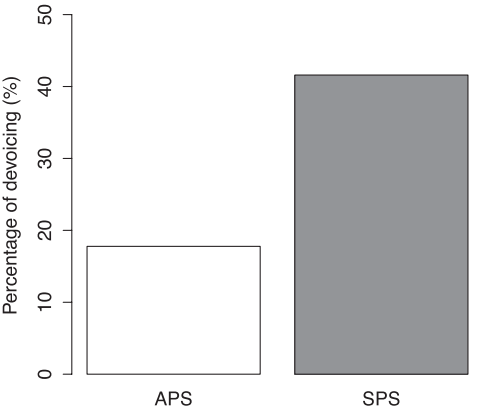

Figure 4. The effect of speech style (APS=Academic Presentation Speech; SPS= Simulated Public Speaking)

3.5. Self-confidence in public speech

Figure 5 shows the effect of self-confidence about public speaking, in which speakers who consider themselves as "not confident" show a high probability of devoicing. There is a clear division between the leftmost category and the other three categories in Figure 5—the actual numbers are provided in Table 2 ($\chi^2(4) = 42.7, p < .001$). To assess this observation statistically, post-hoc tests with a Bonferroni correction ($\alpha = .05/6 = .008$) were run, which show that the first condition is statistically different from the other three (1st vs. 2nd: $\chi^2(1) = 34.6, p < .001$; 1st vs. 3rd: $\chi^2(1) = 32.9, p < .001$; 1st vs. 4th: $\chi^2(1) = 10.0, p < .008$), but that no differences among the last three conditions are significant (2nd vs. 3rd: $\chi^2(1) = 0.1$, *n.s.*; 2nd vs. 4th: $\chi^2(1) = 0.1$, *n.s.*; 3rd vs. 4th: $\chi^2(1) = 0.2$, *n.s.*).[11]

[11] These post-hoc statistical analyses on all the possible comparisons were prompted by an anonymous reviewer.

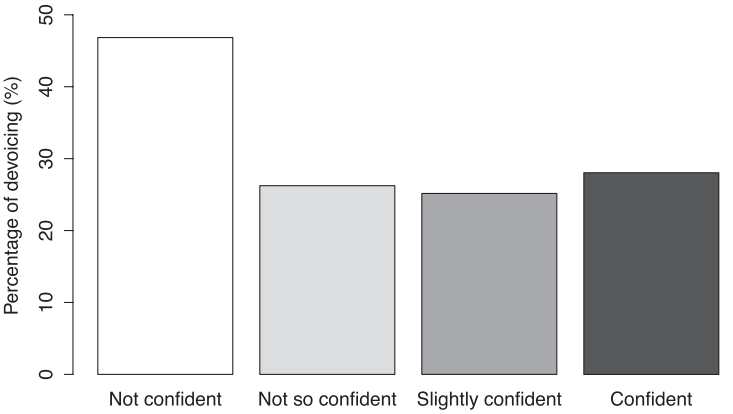

Figure 5. The effect of self-confidence about public speaking

Table 2. The effect of confidence level on devoicability (actual numbers)

	Not confident	Not so confident	Slightly confident	Confident
n	111/237	196/747	119/473	30/107
%	46.8%	26.2%	25.2%	28%

3.6. Educational background

Figure 6 illustrates the effect of educational background of the speakers.[12] The figure shows that the higher the educational background of the speakers, the less likely that they show devoicing (no higher education: 99/209=47.4%; undergraduate: 237/697=34%; graduate: 128/709=18.1%) ($\chi^2(2) = 84.4$, $p < .001$). Post-hoc multiple comparisons with Bonferroni correction ($\alpha = .05/3 = .013$) show that all the differences are significant (no higher education vs. undergraduate: $\chi^2(1) = 11.7$, $p < .001$; no higher education vs. graduate: $\chi^2(1) = 73.0$, $p < .001$; undergraduate vs. graduate: $\chi^2(1) = 45.7$, $p < .001$).

This correlation holds most likely because people with higher education are more likely to know that geminates are voiced in the donor languages, and tend to prefer to use forms that are faithful to the source language. The correlation is also compatible with the sociolinguistic observation that people with higher social class are more likely to use standard forms, while people in lower social classes are more likely to use vernacular forms (Hibiya 1995; Labov 1963, 1972, 1994, 2001b; Trudgill 1974).

[12] In other sociolinguistic studies, social class is more often used as a predictor variable (Labov 1966, 2001b). We use educational background as a replacement, as social class is not a standard classification in the Japanese society and hence is not encoded in the CSJ.

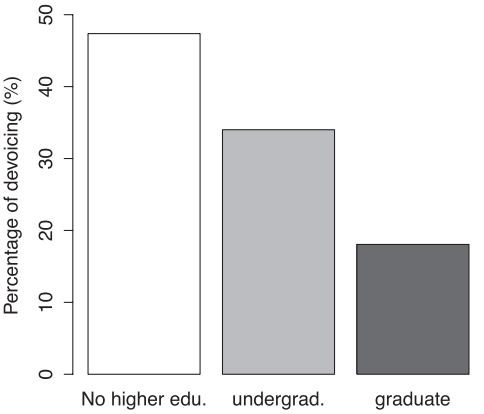

Figure 6. The effect of educational background

3.7. Previous experiences in public speech

Finally, Figure 7, together with Table 3, shows the effect of previous public speaking experiences on devoicing.[13] We observe a general trend in which the more experiences the speakers have, the less likely that devoicing occurs—there is a general decline among the first three conditions, and especially the difference between the second condition and the third condition is apparent. To assess this observation, multiple-comparisons with a Bonferroni correction (α = .05/10 = .005) were run, which show that the differences between the first and the other conditions are significant or marginal (1st vs. 2nd: $\chi^2(1) = 3.3$, $p = .067$; 1st vs. 3rd: $\chi^2(1) = 52.7$, $p < .001$; 1st and 4th: $\chi^2(1) = 28.6$, $p < .001$; 1st vs. 5th: $\chi^2(1) = 70.1$, $p < .001$), that the differences between second and the last three conditions are significant (2nd vs. 3rd: $\chi^2(1) = 22.8$, $p < .001$; 2nd vs. 4th: $\chi^2(1) = 13.1$, $p < .001$; 2nd vs. 5th: $\chi^2(1) = 28.1$, $p < .001$), but that the other differences are minimal (3rd vs. 4th: $\chi^2(1) = 0.00$, *n.s.*; 3rd vs. 5th: $\chi^2(1) = 0.00$, *n.s.*; 4th vs. 5th: χ^2 (1) = 0.00, *n.s.*).

This effect of previous experiences makes sense from the previous observations in Figure 6. Those without much higher education are less likely to have previous public speaking experiences.[14] Therefore, they are more likely to be unaware of—or do not pay careful attention to—the original pronunciations of voiced geminates.

[13] We deployed the categorization coding for the number of public speaking experiences from the CSJ.

[14] There is, in fact, a fairly high correlation between those two factors in our data (r = 0.57). See Section 4 for a multiple logistic regression analysis, which shows that even when these two factors are encoded in the same model, they both have a significant impact on devoicing.

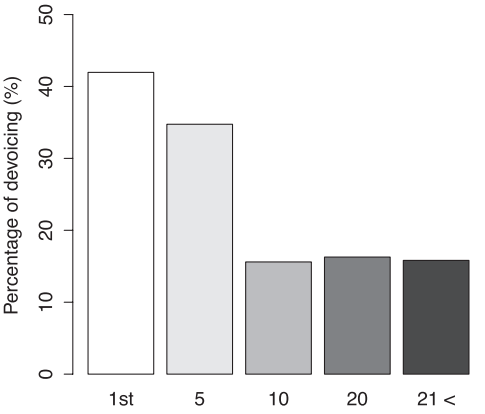

Figure 7. The effect of previous public speaking experiences

Table 3. The effect of previous public speaking experiences (actual numbers)

	1st	5	10	20	21<
n	240/572	82/236	39/250	21/129	59/373
%	42%	34.7%	15.6%	16.3%	15.8%

The last two observations thus converge on one conclusion: geminate devoicing may be to some degree under a conscious control—those who are likely to know the pronunciations of the donor language tend to keep the voicing value of the donor language. As discussed in the previous section, those people may prefer to use forms that reflect the original pronunciations more accurately.

3.8. Other external factors

Other external factors that we investigated, which showed no correlations with the probability of devoicing, include the following: speed (speech rate), spontaneity of the speech, and articulatory clarity.

4. A Logistic Regression Analysis

Although we have seen that several external factors affect the devoicing likelihood of geminates, one may be concerned that some factors are correlated with others, and effects of some factors arise from that correlation. To address this issue, a multiple logistic regression analysis was run with the following model.[15] The

[15] A logistic regression analysis was run because the dependent variable is a binary opposition. We did not encode interaction terms, because encoding interaction terms among all seven factors would make the interpretation of the results extremely hard. We did not use VARBRUL method (Cedergren and Sankoff 1974), because logistic regression is more widely used methodology.

dependent variable was whether a particular token was devoiced or not. The independent variables were the OCP, age, gender, style, self-confidence, educational background, and previous experiences. The self-confidence and previous experiences were recoded because, as we have seen before, their effects were non-linear. Self-confidence was recoded as a binary opposition between "not confident" vs. "everything else", and previous experiences were recoded as a ternary opposition between "1", "5" and "more". The analysis was run by R (R Development Core Team 1993–2013), using the **glm** function.

The result of the logistic regression analysis is shown in Table 4. Almost all the factors still have a significant effect in this multiple regression model, even when all the factors are tested at once. A few exceptions are that educational background is only marginally significant, and that style did not have any significant effect.

Table 4. The result of the logistic regression

	Estimate	StEr	z	p
OCP	2.48477	0.22106	11.240	< .001
Age	0.21390	0.05509	3.883	< .001
Gender	–0.32577	0.15187	–2.145	< .05
Style	–0.22752	0.23053	–0.987	*n.s.*
Self-confidence	–0.62682	0.17163	–3.652	< .001
Educational background	–0.27088	0.14070	–1.925	= 0.054
Previous experience	–0.31134	0.09724	–3.202	< .01

To understand why style did not have a statistical impact in this model, we calculated the correlation matrix of the variables used in this model. The result shows that style had a high correlation with educational background (r = 0.76) and previous speech experience (r = 0.68). It is likely that those who provide APS (Academic Presentation Speech) have high academic background and many previous speech experiences. The lack of significant effect of style in this regression model may be because the variability is subsumed by these two factors.

Except for this factor, however, the impacts of other extralinguistic factors are reliable in the multiple regression model (the effect of educational background was only marginally significant, whose variability may be partially subsumed by previous experiences and other factors). The analysis shows that even when all these factors are encoded in the same model, most of them each have a reliably significant impact on devoicability.

5. General Discussion

This paper investigated the patterns of geminate devoicing in Japanese loanwords using the large-scale corpus, the Corpus of Spontaneous Japanese. A thorough search of this corpus shows (i) that the OCP plays a crucial role in inducing geminate devoicing, (ii) that devoicing does occur even without the presence of another voiced obstruent, although it is much less likely, and (iii), most importantly for the

current purpose, that various external, sociolinguistic factors affect the likelihood of devoicing. The ways in which external factors affect devoicing generally make sense given the findings of the previous sociolinguistic literature: the variation in the devoicing patterns follows the general patterns of language variation and change.

Moreover, we observe some evidence that geminate devoicing may be consciously controllable in the sense that those who are likely to have knowledge of the donor languages may attempt to refrain from devoicing. The overall patterns therefore show that grammar-driven (or markedness-driven) devoicing can be suppressed by conscious control, as reflected in variation patterns affected by various sociolinguistic factors.

In conclusion, our corpus study has confirmed some of the previous observations about geminate devoicing in Japanese loanwords (Nishimura 2003, 2006 *et seq.*), but also has found that many external factors affect the applicability of devoicing. Our results thus contribute to the deeper understanding of the phenomenon by revealing various hitherto unnoticed factors that affect the likelihood of devoicing. We hasten to add, however, that our aim in conducting this project is in no way in conflict with the previous studies of the devoicing phenomenon, which did not consider external, sociolinguistic factors. Instead, it is hoped that further research will seek for a deeper understanding of the phenomenon by considering—and modeling—how both linguistic and external factors shape devoicing patterns.

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【要　旨】

コーパスを用いた日本語有声促音の無声化に関する研究
――必異原理と言語外的要因の役割――

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Nishimura（2003, 2006）は，日本語の借用語における有声促音が他の有声阻害音と共起する場合，無声化し得ると指摘している。この無声化のパターンについては，これまで理論・実験の観点から多くの分析があり，理論的諸問題の解決に貢献してきている。しかしながら，自然発話のデータを基にした研究はほとんど例がなく，社会言語学的な要因も仮定されていない。これらの背景を踏まえ本稿にて『日本語話し言葉コーパス』を用いて検証を行った結果，以下の 2 点が確認された。まず先行研究において確認されている，必異原理が有声促音の無声化を促進する効果が自然発話データにおいても確認された。次に，多くの言語外的・社会言語学的要因が無声化の適用・不適用に影響を与えているということが確認された。本稿における取り組みにより，これまでの研究で注目されることのなかった無声化のパターンを統御する潜在的要因が新たに明らかとなった。