Two Is Too Much: Geminate Devoicing in Japanese*

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ABSTRACT. This paper analyzes devoicing of geminates induced by singleton [p] in Japanese loanwords, as well as that induced by voiced obstruents (Nishimura 2003 *et seq.*). Corpus analyses and judgment experiments reveal that [p] can optionally devoice a voiced obstruent geminate in Japanese loanwords, as in /**p**irami**dd**o/ → [**p**irami**tt**o] "pyramid" (Kawahara and Sano 2014). An analysis of type and token frequency of the entire Japanese lexicon shows that [p] and voiced geminates are the two most rare segments in the Japanese lexicon. We argue that their low lexical frequencies may be responsible for the [p]-induced devoicing. To formalize this idea, we propose a new constraint, OCP(unfamiliar), within the framework of Harmonic Grammar (Pater 2009). Not only does the proposal offer a plausible analysis of geminate devoicing, it brings up a new theoretical perspective: different lexical strata in a single language should be treated as part of a single grammatical system (Fukazawa et al. 1998; Ito and Mester 2003).

Keywords: geminate devoicing, lexical strata, lexical frequency, corpus study, [p], Harmonic Grammar

1. Introduction

It is often observed in a language with two or more lexical strata that some phonological structures are banned in one stratum, but allowed in others. In Japanese, three phonological structures instantiate such stratum-dependent distributions: (i) two voiced obstruents within a morpheme, (ii) a voiced (obstruent) geminate, and (iii) a singleton [p], as shown and exemplified in (1). These three phonological structures are prohibited in the phonotactics of the Yamato (=native) stratum (Ito and Mester 1999, 2003). Additional evidence for (1i) comes from rendaku, a phenomenon in which the initial segment of the second member of a compound becomes voiced. In case it results in two voiced obstruents within a morpheme, rendaku is blocked; i.e., [kita-**k**a**z**e] "north wind," not *[kita-**g**a**z**e]—this blockage of rendaku has long been known as Lyman's Law.

(1) The prohibition against three types of structures in the Yamato stratum

Constraints:	(i) *[d…d]	(ii) *[bb, dd, gg, zz]	(iii) *[p]
Examples:	*[kita**g**aze]	*[to**gg**e]	*[**p**ikari]

On the other hand, these three structures are allowed in the Foreign stratum, which consists of recent loanwords from other languages, mainly from English. The loanwords with those structures are all acceptable, as exemplified in (2).

(2) Example words containing these structures in the Foreign stratum
(i) [**b**a**g**u] "bug" (ii) [e**gg**u] "egg" (iii) [**p**agu] "pag dog"

In previous work on lexical stratification in Optimality Theory (OT: Prince and Smolensky 1993/2004), such differences between the Yamato and Foreign strata have been explained by positing the constraint ranking in (3), in which the FAITH constraint for the Foreign stratum outranks three MARKEDNESS constraints—OCP[voice] (=Lyman's Law), *DD, and *[p]—which in turn outrank the FAITH constraint for the Yamato stratum (e.g., Fukazawa et al. 1998; Ito and Mester 1999, 2003). OCP[voice] prohibits two voiced obstruents within the same morpheme; *DD prohibits voiced geminates; and *[p] forbids a singleton [p].

(3) The OT constraint ranking in Japanese
FAITH(Foreign) » MARKEDNESS (OCP[voice], *DD, *[p]) » FAITH(Yamato)

Although (3) is a single invariant ranking, it can be viewed as consisting of two subparts. The first subpart—FAITH(Foreign) » MARKEDNESS—explains why the three phonological

structures in (1) are possible in the Foreign stratum, while the second sub-ranking—MARKEDNESS » FAITH (Yamato)—accounts for the prohibition against them in Yamato words.

However, this is not the end of the story. Although each of the structures in (1) is possible in foreign words, as in (2), when two of them co-occur, then the co-occurrence may become impossible even in the Foreign stratum. A well-known case is when a voiced geminate occurs with another voiced obstruent within a morpheme; this geminate can be devoiced, as in [**d**o**gg**u] "dog" becoming [**d**o**kk**u] (Nishimura 2003; Kawahara 2014, for a review). The cause of this devoicing may be the simultaneous violation of OCP[voice] and *DD.

A similar, but less well-known, case is the observation that a geminate can devoice when a singleton [p] co-exists within the same morpheme, such as [**p**a**dd**o] "pad" optionally becoming [**p**a**tt**o] (Kawahara and Sano 2014). This [p]-driven devoicing of geminates is the focus of this paper. We suggest that [p]-driven devoicing occurs because Yamato-specific restrictions still have an effect on the acquisition of the phonology of the Foreign stratum. In other words, the data of geminate devoicing suggests that Yamato and Foreign strata belong to the same language, namely, Japanese. This conclusion may sound trivial at first, but it is not, given that in OT, the difference between the Yamato and Foreign strata is explained in the same way as the difference between Japanese and, say, English. In other words, although it is true that the Japanese phonological lexicon may need to be stratified (Ito and Mester 1999), it is also important to treat these separate strata as belonging to a single grammatical system (see also Fukazawa et al. 1998; Ito and Mester 2003:135–136).

In what follows, we first describe and analyze the data of geminate devoicing, particularly in words that contain both a singleton [p] and a voiced geminate. To this end, section 2 summarizes the results of Kawahara and Sano (2014), who present both corpus and experimental evidence bearing on the [p]-driven geminate devoicing pattern. Section 3 analyzes the devoicing pattern within the framework of Harmonic Grammar (Legendre et al. 1990; Pater 2009), by proposing a new constraint OCP(unfamiliar). Section 4 examines an alternative analysis with Local Conjunction (Smolensky 1993), and shows why the current analysis is superior. Section 5 discusses general theoretical implications of our analysis.

2. Geminates devoice with a singleton [p]: Kawahara and Sano (2014)

2.1 An impressionistic observation

Let us first examine the basic patterns of geminate devoicing caused by [p]. When a singleton [p] co-occurs with a voiced geminate, the geminate can devoice, as exemplified in the words in (4). (One may wonder what would happen to a word with a geminate [pp] and a voiced geminate: unfortunately, words with two geminates barely exist: Ito and Mester 2003:49–50.) The data in (4) are based on the authors' intuition, as per the traditional generative approach.

(4) Geminate devoicing in words of the form [p…dd]

/**p**a**dd**o/	→	[pa**tt**o]	"pad"
/kyu**p**i**dd**o/	→	[kyuupi**tt**o]	"cupid"
/ra**p**i**dd**o/	→	[rapi**tt**o]	"rapid"
/**p**irami**dd**o/	→	[piramI**tt**o]	"pyramid"
/ai**p**o**dd**o/	→	[aipo**tt**o]	"iPod"
/tetora**p**o**dd**o/	→	[tetorapo**tt**o]	"tetra pod"

2.2 An analysis of the CSJ

This intuition-based data is further corroborated by the analysis of the Corpus of Spontaneous Japanese (the CSJ: Kokuritsu Kokugo Kenkyujo 2008), which shows that geminates devoice more often when they co-occur with a singleton [p] or with a voiced obstruent than elsewhere (Kawahara and Sano 2014). As shown in (5), in the CSJ, geminates appear as devoiced 66% of the time with a voiced obstruent, and 27% of the time with a

singleton [p], while only 4% of the time elsewhere. The differences between the [p]-conditions and the other two conditions are statistically significant (Fisher's exact test: [p] vs. [+voi], $p < 0.001$; [p] vs. elsewhere, $p < 0.01$).

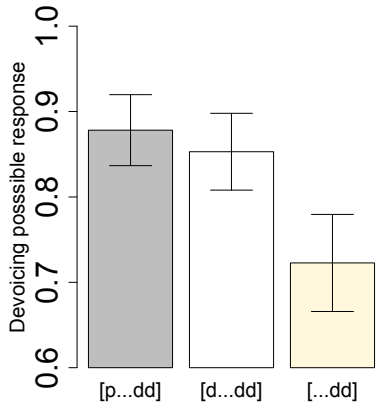
(5) The CSJ analysis: the number of occurrences of the faithful (= voiced) renditions and devoiced renditions of geminates, according to the three phonological environments. See Kawahara and Sano (2014) for details.

Trigger	Faithful	Devoiced	% Devoiced
[p]	11 (e.g., [**p**a**dd**o])	4 (e.g., [**p**a**tt**o])	27%
voiced obstruent	163 (e.g., [ri**j**i**dd**o])	313 (e.g., [ri**j**i**tt**o])	66%
elsewhere	689 (e.g., [sumo**gg**u])	28 (e.g., [sumo**kk**u])	4%

2.3 Experimental data

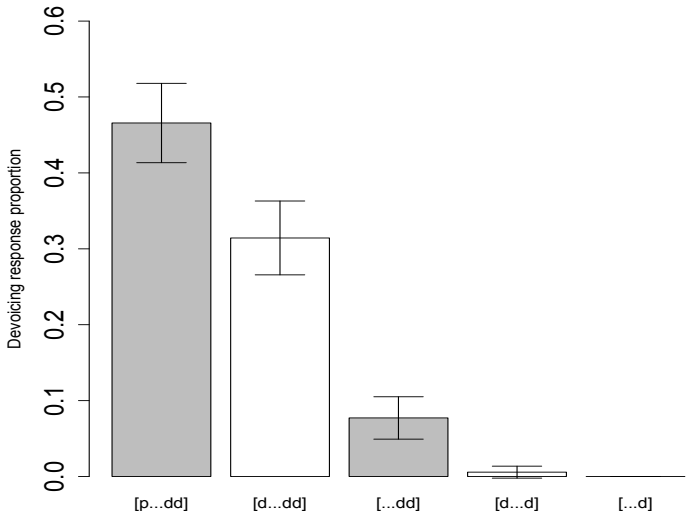
This section briefly reviews two experiments reported in Kawahara and Sano (2014). In their Experiment I, Japanese speakers were asked whether devoicing is possible or not for each lexical item. There were three conditions: (i) words with a singleton [p] and a voiced geminate (e.g., [**p**a**dd**o]); (ii) words with a voiced obstruent and a voiced geminate (e.g., [**b**a**dd**o]); (iii) words with a voiced geminate but without [p] or a voiced obstruent (e.g., [ma**dd**o]). The results in (6) show that participants judged devoicing of geminates to be possible 87% of the time with a singleton [p], 85% with a voiced obstruent, and 72% elsewhere. The differences between the first two conditions and the elsewhere condition were statistically significant.

(6) Experiment I (Kawahara and Sano 2014)



In Experiment II, Japanese speakers were asked which form, voiced or devoiced, they use for a given pair of forms. For instance, [paddo] and [patto] were presented, and then they judged which form they actually use. In this experiment, in addition to the three conditions used in Experiment I, two conditions were added; (iv) words with two singleton voiced obstruents, and (v) words with one singleton obstruent. As shown in (7), more than 30% of the responses were the devoiced responses in the first two conditions, while less than 10% were in the other three conditions. Almost half of the responses were the devoiced responses, when a geminate appears with a singleton [p] (the leftmost bar). The difference between the [p…dd] condition and the […dd] condition is thus more pronounced in Experiment II than in Experiment I.

(7) Experiment II (Kawahara and Sano 2014)



The overall results of Kawahara and Sano (2014), briefly reviewed here, thus show that a geminate tends to be more devoiced with a singleton [p] or with a voiced obstruent than elsewhere. The next section analyzes these patterns of geminate devoicing within the framework of Harmonic Grammar (HG: Legendre et al. 1990).

3. An HG Account for geminate devoicing

3.1 Geminate devoicing in [D + DD] words

First, as a background, we review the analysis of geminate devoicing pattern developed by Pater (2009), in which he analyzed only devoicing of geminates co-occurring with another voiced obstruent (see also Kawahara 2014). Pater (2009) argues that HG allows us to derive the effect of geminate devoicing caused by another voiced obstruent without a stipulation (cf. Nishimura 2003 who uses local conjunction to derive this effect). We show in section 3.2, however, that even in this framework, [p]-driven devoicing does not arise automatically.

Unlike OT in which the constraints are ranked, each constraint in HG is assigned some *weight*. A harmonic score for each candidate is a weighted sum of each constraint violation (Harmony=$\sum w_i * v_i$ where w=weight; v=violation profiles). The candidate with the highest harmonic score wins. As shown in the tableaux in (8), let the weight of FAITH for voicing be 2, and that of the other constraints (*DD, *[p], and OCP[voiced]) be 1.5. In this analysis, the precise values of these weights are not relevant, as long as two arithmetic conditions are met: (i) the weight of FAITH is higher than those for the markedness constraints, and (ii) the sum of the weights of *DD and OCP[voiced] is higher than that of FAITH, as we will see.

For the case of /bado/, the first faithful candidate [bado] violates OCP[voice], since it has two voiced obstruents, [b] and [d]. Therefore, its harmonic score is -1.5 (=1.5 times -1). On the other hand, the second candidate [bato] with devoicing violates FAITH, resulting in the harmonic score of -2. Thus, the first candidate [bado] becomes a winner, because its harmonic score is higher—closer to zero—than that of [bato] (-1.5 > -2).

The second input is /heddo/, which has a voiced geminate. The faithful candidate [heddo] violates *DD, resulting in the harmonic score of -1.5. The second candidate [hetto] violates FAITH, and its harmonic score is -2. Therefore, the faithful one [heddo] becomes the actual output, because of its higher harmonic score (again, -1.5 > -2).

In contrast to these two cases, when a voiced obstruent and a voiced geminate co-occur, the first candidate [beddo] which is faithful to the input violates both *DD and OCP[voice]; therefore, its harmonic score is -3.0 (= -1.5 + -1.5). On the other hand, a devoiced candidate

[betto] violates only FAITH, with the resulting harmonic score of -2.0. Hence, the devoiced candidate [betto] wins in this evaluation. What we observe here is a so-called "gang-effect" in which lower weighted constraints gang up to triumph over a higher-weighted constraint. A gang effect occurs because one violation of FAITH simultaneously satisfies the violations of two lower-weighted markedess constraints.

(8) An HG analysis of geminate devoicing by Pater (2009)

		FAITH	*DD	*[p]	OCP[voi]	Harmony
		2	1.5	1.5	1.5	
/bado/	☞bado				-1	-1.5
	bato	-1				-2.0
/heddo/	☞heddo		-1			-1.5
	hetto	-1				-2.0
/beddo/	beddo		-1		-1	-3.0
	☞betto	-1				-2.0

3.2 Geminate devoicing in [p] + DD words

3.2.1 OCP(unfamiliar)

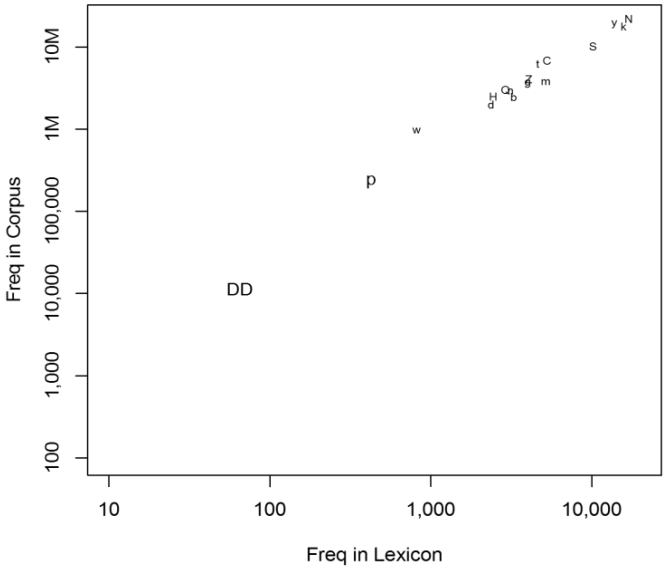
Now if we were to apply the same analysis for [p]-driven geminate devoicing, OCP[voice] does not work, since we do not have two voiced obstruents. Therefore, we propose a new constraint OCP(unfamiliar) which bans two "unfamiliar" elements within a word. This constraint is based on two intuitive ideas: (i) both singleton [p]s and voiced geminates are, despite being allowed in loanwords, still foreign, infrequent and unfamiliar, and (ii) it may be that Japanese speakers do not like to tolerate the co-occurrence of two such infrequent, unfamiliar structures. We conjecture that the constraint OCP(unfamiliar) itself is universal, but the choice of the unfamiliar elements is language specific. An underlying assumption for this mechanism is the hypothesis that children can identify infrequent, unfamiliar structures in the process of their language acquisition.

We now show that a singleton [p] and a voiced geminate are both indeed infrequent structures in Japanese.

3.2.2 Supporting data for the unfamiliarity of [p] and DD

As an objective support of this proposal, the figure in (9) shows the lexical frequency of each phoneme in Japanese. The y-axis shows the (token) frequency of the corpus data consisting of 10 years from the Asahi Newspaper, and the x-axis shows the (type) frequency data taken from the 80,000-word Shinmeikai Kokugo Dictionary (Amano and Kondo, 1999). Both the type and token frequencies of voiced geminate [DD] and singleton [p] are the lowest two among all phonemes in Japanese. It therefore seems safe to assume that children acquiring Japanese would think that both a singleton [p] and a voiced geminate are unfamiliar elements in Japanese. With this, OCP(unfamiliar) in Japanese would penalize any morpheme that contains both [p] and a voiced geminate.

(9) Type and token frequency of phonemes in Japanese



3.3.3 Geminate devoicing in [p + DD] words

With the new constraint OCP(unfamiliar), we now develop an HG analysis of geminate devoicing caused by a singleton [p]. In addition to those constraints used in (8), the tableaux in (10) have OCP(unfamiliar). We assign the same weight to OCP(unfamiliar) as that of OCP[voice] (1.5; however, as shown below, any weight higher than 0.5 would actually work). Recall that OCP(unfamiliar) penalizes the structure [p…dd].

Given an input like /paddo/, a devoiced candidate [patto] has a better harmonic score than the faithful candidate [paddo], because the latter candidate violates three markedness constraints *DD, *[p], and OCP(unfamiliar), resulting in the harmonic score -4.5, while the devoiced candidate [patto] violates only FAITH and *[p], resulting in -3.5. Importantly, without OCP(unfamiliar), [paddo] would receive a harmonic score of -3, and hence would not lose against [patto]. Just deploying HG—without OCP(unfamiliar)—does not account for [p]-driven devoicing by itself, unlike Pater's (2009) analysis of OCP(voice)-driven geminate devoicing. A gang effect does *not* occur here, because devoicing a geminate in words like [paddo] does not simultaneously resolve a violation of OCP[voice] and that of *DD. (For this reason, our analysis is directly translatable to OT, unlike that of Pater (2009).)

In words without a voiced geminate, a faithful candidate [pagu] has a better harmonic score than the devoiced candidate [paku], because the faithful one violates only *[p]. Devoicing here is fortuitous.

(10) Devoicing in [p + DD]

		FAITH	*DD	*[p]	OCP[voi]	OCP(unfam)	Harmony
		2	1.5	1.5	1.5	1.5	
/paddo/	paddo		-1	-1		-1	-4.5
	☞patto	-1		-1			-3.5
/pagu/	☞pagu			-1			-1.5
	paku	-1		-1			-3.5

The tableaux in (11) show that the patterns of geminate devoicing examined in (8) still hold with OCP(unfamiliar). Since none of the structures—/bado/, /heddo/, and /beddo/—

contains two unfamiliar elements (a voiced geminate or a singleton [p]), the constraint OCP(unfamiliar) is satisfied, and hence its addition does not affect their harmonic scores.

(11) Devoicing in [D + DD] with OCP(unfamiliar)

		FAITH	*DD	*[p]	OCP[voi]	OCP(unfam)	Harmony
		2	1.5	1.5	1.5	1.5	
/bado/	☞bado				-1		-1.5
	bato	-1					-2
/heddo/	☞heddo		-1				-1.5
	hetto	-1					-2
/beddo/	beddo		-1		-1		-3
	☞betto	-1					-2

4. On the analysis with Local Conjunction

Let us now address one obvious alternative: local conjunction (Smolensky 1993). Nishimura (2003) analyzed the geminate devoicing caused by OCP[voice] with a locally conjoined constraint; i.e., $\{\text{OCP[voice]} \,\&\, \text{*DD}\}_{\text{stem}}$. Similarly, it would be possible to analyze [p]-driven geminate devoicing with a constraint like $\{\text{*[p]} \,\&\, \text{*DD}\}_{\text{stem}}$. The analyses with such a locally-conjoined constraint would formally be equivalent to our HG analyses: given our case, OCP(unfamiliar) and $\{\text{*[p]} \,\&\, \text{*DD}\}_{\text{stem}}$ would assign the same violation profiles to the candidates considered here.

However, we contend that OCP(unfamiliar) is better than the locally-conjoined constraint $\{\text{*[p]} \,\&\, \text{*DD}\}_{\text{stem}}$, because unrestricted use of local conjunction will lead to an unrestrictive theory (e.g., Fukazawa and Lombardi 2003). To the extent that constraints like [p] and *DD can be conjoined in a domain as large as stem, the theory would have to allow any two constraints to be conjoined in a domain of stem. Such a grammatical model would be too powerful and too unrestrictive. For example, there is nothing that would prevent us from positing a constraint like $\{\text{*[+nasal]} \,\&\, \text{*[pp]}\}_{\text{stem}}$, which prohibits geminate [pp] only when there is a nasal consonant within the same stem. Unlike the local conjunction analysis, the current analysis ties [p] and voiced geminates together in terms of their low lexical frequencies, or their perceived unfamiliarity. There would be no such ties in the local conjunction analysis.

5. Conclusion

This paper has analyzed the patterns of geminate devoicing, both when triggered by singleton [p] and when triggered by a voiced obstruent. We have shown that geminate devoicing data illustrate how the three phonological structures—two voiced obstruents in a word, a voiced geminate, and a singleton [p]—behave in the Foreign stratum: one of the three elements is possible, but *two can be too much* (notwithstanding that devoicing of singleton consonants is still impossible). The analysis suggests that structures like singleton [p] and voiced geminates, although they are allowed in the Foreign stratum, are still marked: their effects are still tangible in the patterns of geminate devoicing. We have demonstrated that HG with OCP(unfamiliar) provides a plausible analysis of the devoicing patterns.

One prominent remaining issue, which was set aside in the current paper, is the optionality —and probability—of devoicing. Future studies should address the optionality of geminate devoicing. Some promising lines of research have already been hinted at by Coetzee and Kawahara (2013) who use Noisy Harmonic Grammar, and Coetzee and Pater (2011) who use

a MaxEnt Grammar. These models would allow us to calculate exact constraint weight values based on the probabilities of devoicing in the actual production pattern. However, we would like to leave this topic for future research, as we think it merits its own paper.

Before closing the paper, we would like to make one final concluding remark. In OT or HG, cross-linguistic differences are explained by differences in constraint rankings or weightings. Ultimately, whether a structure is allowed or not boils down to a difference between "FAITHFULNESS » MARKEDNESS", or "MARKEDNESS » FAITHFULNESS": the difference between the two languages (e.g., Japanese vs. English) and the difference between two strata within one language are explained by the same mechanism.

However, the analysis of geminate devoicing in Japanese shown above connects the Foreign stratum to the Yamato stratum. The markedness constraints that are active in the native words—*DD and *[p]—would make some structures infrequent or unfamiliar in the entire lexicon of Japanese; through OCP(unfamiliar), these markedness constraints would impact on a pattern in loanword phonology. Therefore, despite being stratified, Foreign and Yamato must belong to one single grammatical system, i.e., Japanese.

Notes

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