/p/-driven geminate devoicing in Japanese: Corpus and experimental evidence

Abstract

It is well-known that in Japanese loanwords, voiced geminates can be devoiced in the presence of another voiced obstruent (e.g. /**d**o**gg**u/ → /**d**o**kk**u/). This devoicing pattern has been studied extensively in the recent phonological literature, in terms of theoretical modeling as well as from the perspective of experimentation and corpus studies. Less well-known is the observation that /p/ may cause devoicing of geminates as well (e.g. /**p**irami**dd**o/ → /**p**irami**tt**o/), although to date no objective evidence has been offered to confirm this observation. The current study thus attempts to test this observation objectively, by way of a corpus study and two phonological judgment experiments. All the results generally support the idea that /p/ causes devoicing of geminates in loanwords. In addition to this descriptive discovery, throughout the paper we discuss intriguing task effects in phonological experimentation, by comparing the corpus data and the results of the two experiments. Although our aim is primarily descriptive, we offer some analytical possibilities for the /p/-driven devoicing of geminates toward the end of the paper.

1   Introduction

It is well known since Nishimura's (2003) discovery that in Japanese loanword phonology, voiced geminates optionally devoice when they co-occur with another voiced obstruent; e.g. /**d**o**gg**u/ 'dog' can be pronounced as /**d**o**kk**u/, but /e**gg**u/ 'egg' cannot be pronounced as */e**kk**u/.[1] In other words, a restriction against two voiced obstruents—a constraint known as Lyman's Law or the OCP(voice) in the native phonology (Ito & Mester, 1986, 2003; Vance, 2007)—causes devoicing of geminates. What makes this pattern even more interesting is the fact that OCP(voice) does not seem to devoice singletons (e.g. /**b**a**g**u/ → */**b**a**k**u/ 'bug').

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[1]This paper uses phonemic transcription (Vance, 1987, 2008) rather than IPA transcription for the sake of typographical ease, as the phonetic details do not matter much in this paper.

This devoicing of geminates has been studied extensively within various theoretical frameworks (Coetzee & Kawahara, 2013; Coetzee & Pater, 2011; Crawford, 2009; Farris-Trimble, 2008; Ito & Mester, 2008; Hayes, 2009; Kawahara, 2006, 2008; McCarthy, 2008; Nishimura, 2003, 2006; Pater, 2009, to appear; Rice, 2006; Tesar, 2007; Tsujimura, 2014), and has been used to argue for several theoretical apparatuses, such as local conjunction (Nishimura, 2003, 2006), Harmonic Grammar (Farris-Trimble, 2008; Pater, 2009, to appear), and Max-Ent Grammar (Coetzee & Pater, 2011), among others. This OCP-driven devoicing pattern has also been studied experimentally (Kaneko & Iverson, 2009; Kawahara, 2011a,b, 2013), as well as from the perspective of corpus-based studies (Kawahara & Sano, 2013; Sano, 2013; Sano & Kawahara, 2013). It thus seems safe to say that this OCP-driven devoicing pattern has received substantial attention in the field in the last ten years or so, not exclusively among those who are interested in Japanese phonology *per se*, but also among those who work in the field of phonological theory in general.

Against this background, this paper points out a less well-known—but yet important—complication to this devoicing pattern. That is, it seems to be the case, at least according to our (admittedly biased) intuition, that geminates can devoice when they co-occur with /p/ as well; e.g., /kyuu**pitt**o/ 'cupid' and /**p**irami**tt**o/ 'pyramid'. If our intuition is correct, then it is not only the OCP(voice), but also the co-occurrence with /p/, that can cause devoicing of geminates. This /p/-driven devoicing would probably come as a surprise to many phonologists, because having /p/ and having a voiced geminate seem phonologically mutually irrelevant. If this pattern does indeed exist in the contemporary phonology of Japanese, it would also require significant revisions to the theoretical analyses of the OCP-driven geminate devoicing pattern cited above, because the co-occurrence of /p/ and voiced geminates should not violate the OCP(voice).

The pattern of /p/-driven devoicing, however, would probably be taken to be surprising by many practicing phonologists, and can be viewed with suspicion, because as far as we are aware, no other languages show a pattern of devoicing caused by /p/ at a distance. This apparently surprising pattern should probably not be used for phonological argumentation when it is purely based on the authors' own intuition (Labov, 1996; Schütze, 1996). Therefore, this /p/-driven devoicing pattern requires careful empirical scrutiny.

To summarize, this paper aims to verify this /p/-driven devoicing of geminate using objective methods, because (i) this /p/-driven devoicing of geminates is a surprising non-local interaction between two phonological structures, and because (ii) if this /p/-driven devoicing is a real process, then the previous analyses of geminate devoicing need to be revised. To that end we report one corpus-based study and two judgment experiments to explore the reality of the /p/-driven devoicing. The judgment experiments build on the

previous judgment experiments on OCP-driven devoicing of geminates (Kawahara, 2011a,b, 2013).

The rest of this paper is structured as follows. A corpus-based analysis is reported in Section 2. Experiment I used a yes/no format, which shows that /p/ does induce more "devoicing possible" responses than other consonants. Experiment II asked the participants which form—voiced or devoiced—they actually use in a forced-choice format, which again supports the reality of /p/-driven devoicing. In addition, the comparison of these two experiments reveals an interesting task effect in phonological experimentation. Section 5 discusses some possible theoretical analyses. The final section is a conclusion.

2   A corpus-study based on the CSJ

We first analyzed the Corpus of Spontaneous Japanese (the CSJ) (NINJAL, 2008). This corpus is one of the largest corpora of spoken Japanese, containing about 7.5 million words, which is equipped with rich annotation systems. It also encodes underlying forms as well as actual pronounced forms, and this feature allows us to access the devoicing status of geminates (see Kawahara & Sano 2013; Maekawa et al. 2000 for further details).

We first extracted all the words containing a voiced geminate, and classified them into three categories: (i) those that occur with /p/, (ii) those that occur with a voiced obstruent, and (iii) those that would fit neither of the structural descriptions (henceforth the "elsewhere" condition).[2] We then examined whether these geminates appear as voiced or devoiced in the corpus for each condition. The results are shown in Table 1.

Table 1: The results of the search of the CSJ: the second column shows the number of geminates appearing as voiced; the third column the number of geminates appearing as devoiced. The rightmost column shows the percentages of devoiced tokens.

	voiced	devoiced	total	percent devoiced
/p/ (e.g. /paddo/)	11	4	15	26.7%
[+voice, -son] (e.g. /beddo/)	163	313	476	65.8%
elsewhere (e.g. /heddo/)	689	28	717	3.9%

The bottom row shows that geminates rarely appear as devoiced when they do not

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[2]We put double quotes around "elsewhere", in order to distinguish it from the Elsewhere Condition, one of the principles deployed in Lexical Phonology (Kiparsky, 1982)

appear either with /p/ or a voiced obstruent. This result shows that context-free devoicing of geminates rarely occurs. The second row shows that geminates appear as voiceless 65.8% of the time when they appear with a voiced obstruent. The top row shows that although /p/ does not cause devoicing as much as a voiced obstruent, the devoicing percentage is higher than the third row, the "elsewhere" condition.

We fully admit that the N for the /p/-condition is small (the top row; N=15), and that we should not be conclusive about the productivity of /p/-driven devoicing based on these data alone. Nevertheless, Fisher's Exact tests show that /p/'s devoicing proportion is higher than the "elsewhere" condition ($p < .01$), although it is lower than the devoicing proportion by a voiced obstruent ($p < .01$). Again, we should not conclude based on this data that /p/ causes devoicing of geminates, because the relevant number of items is small. We thus followed up this corpus-based study with phonological judgment experiments.

3 Experiment I: A yes/no judgement task

Experiment I used a task in which the participants judged, for each given item, whether devoicing is possible or not in a yes/no format. This experiment followed the methodology of Kawahara (2013).

3.1 Method

3.1.1 Task

Within each trial, the participants were given one word containing a geminate. They were then asked if devoicing that geminate was possible or not. For example, they were asked: "given the word *kyuupiddo*, is it possible to pronounce it as /kyuupitto/?"

3.1.2 Stimuli

The stimuli consisted of a set of real words and another set of nonce words. Within each set, there were three conditions: (i) those that contain /p/, (ii) those that contain a voiced obstruent, and (iii) those that contain neither.[3] Seven items were included in all conditions; we could find only seven real words that fit the structural description of (i) (at the time of the experiment). The place of articulation was controlled across the three conditions; six items contained geminate /dd/ and one item contained geminate /gg/ for the real word stimuli;

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[3]One may wonder what would happen to words containing a geminate /pp/—not a singleton /p/—and a voiced geminate. Unfortunately, Japanese prohibits words with two geminates (Ito & Mester, 2003), which does not allow us to test such structures.

this unbalance was necessitated by the fact that there are not many words that contain /p...gg/. For the nonce word stimuli, for each condition, there were four items containing /dd/ and three items containing /gg/.

The experimental items for the real words and nonce words are provided in Table 2 and Table 3, respectively. The real words for the /p/-condition were largely based on those that were found in the CSJ.

Table 2: The real word stimuli.

/p...dd/		/b...dd/		/...dd/	
/kyuupiddo/	'cupid'	/baddo/	'bad'	/heddo/	'head'
/paddo/	'pad'	/beddo/	'bed'	/reddo/	'red'
/aipaddo/	'i-pad'	/deddo/	'dead'	/uddo/	'wood'
/aipoddo/	'i-pod'	/guddo/	'good'	/kiddo/	'kid'
/supureddo/	'spread'	/daddo/	'dad'	/maddo/	'mad'
/piramiddo/	'pyramid'	/goddo/	'god'	/roddo/	'rod'
/piggu/	'pig'	/biggu/	'big'	/eggu/	'egg'

Table 3: The nonce word stimuli.

/p...dd/	/b...dd/	/...dd/
/piddo/	/biddo/	/meddo/
/poddo/	/buddo/	/ruddo/
/puddo/	/boddo/	/yoddo/
/peddo/	/doddo/	/taddo/
/paggu/	/boggu/	/uggu/
/puggu/	/goggu/	/oggu/
/peggu/	/gaggu/	/noggu/

3.1.3   Procedure

The experiment was run online using Surveymonkey.[4] The participants were told that within each trial, they would be given one form, and another pronunciation, and would be asked if the latter form is a possible pronunciation of the first form. For the real word stimuli, the participants were told that all the stimuli would be existing loanwords. For the nonce word stimuli, they were told the stimuli were non-existing words in Japanese. All the stimuli were

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[4]Several experiments have shown that online experimentation is as reliable as experiments conducted in a laboratory setting (Reips, 2002; Sprouse, 2011; Yu & Lee, 2014).

written in the *katakana* orthography, which is usually used for loanwords and nonce words. The real words and nonce words were separated into two different blocks, with a self-timed break in-between, and the block for the real word stimuli was presented first. Within each block, the order of the stimuli were randomized per participant by Surveymonkey.

In the instructions, the participants were asked to read the stimuli in their head, and use the auditory impression to respond to the questions.

3.1.4   Participants

The participants were recruited by word of mouth and through advertisement on a social networking service. Thirty-four native speakers of Japanese completed the online experiment.

3.1.5   Statistics

Since the response was binary (devoicing possible or devoicing impossible), ANOVA was avoided, and instead logistic linear mixed effects model analyses were run (Baayen et al., 2008; Jaeger, 2008). Subjects and items were encoded as random factors. Both slopes and intercepts of random effects were included in the models to have the maximal random structure, following the recent suggestions by Barr (2013) and Barr et al. (2013).

3.2   Results

Figure 1 shows the proportions of devoicing possible responses for each condition for real word stimuli, with error bars representing 95% binomial confidence intervals. It shows that the first two bars show higher devoicing proportions than the third bar (87.8%, 85.3% vs. 72.3%).

The first linear mixed model comparing all the three conditions shows that there is a statistically significant difference among the three conditions ($z = 2.52, p < .05$). Subsequent contrast analyses show that the difference between the first condition (the /p/-condition) and the third condition (the "elsewhere" condition) is significant ($z = 2.50, p < .05$). The difference between the first two conditions was not significant, however ($z = 0.05, n.s.$). This result supports that /p/ indeed causes devoicing of geminates in Japanese, which is also compatible with the patterns found in the corpus, shown in Table 1.

Despite the fact that the overall patterns are compatible with what is expected from the patterns in the corpus, as well as our own intuition, the devoicing possible responses are overall unexpectedly high. This issue is taken up on in the discussion section as well as in Experiment II.
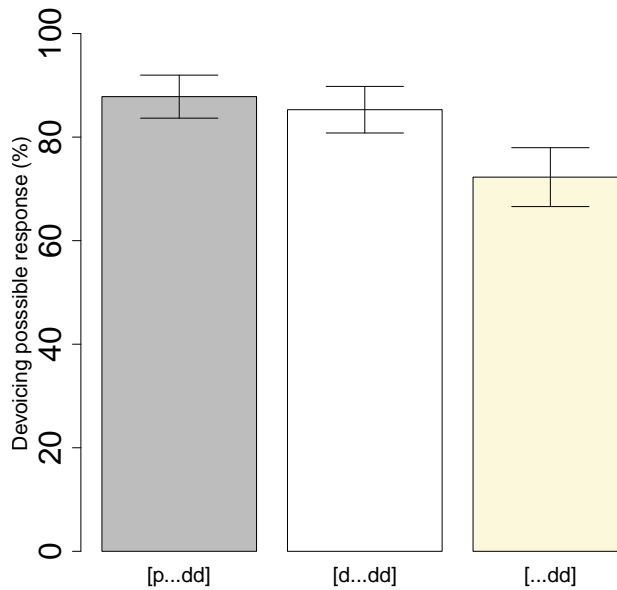
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Figure 1: The proportions of devoicing possible responses for each condition: Real words.

Figure 2 shows the results of nonce words. Although the third condition shows slightly low devoicing possible responses compared to the first two (79.8%, 80.7% vs. 77.3%), the differences were very small; about 2.5%. In fact, a linear mixed model analysis comparing the three different conditions shows no statistically significant differences ($z = 0.03, n.s.$).

3.3 Discussion

The results of the real words show that naive native speakers of Japanese have an intuition that /p/ can cause devoicing at least more than the "elsewhere" condition, just like our own possibly biased intuition.

One immediate point to notice, however, is the overall differences between the results of the experiment and the patterns in the corpus. For example, /p/-driven devoicing was judged to be possible 87.8% of the time in experiment, but in the corpus, actually 26.7% of geminates appear as devoiced. This discrepancy is more notable in the "elsewhere" condition; in the experiment 72.3% of them were considered to be devoicable, whereas in the actual corpus, only 3.9% of them appear as devoiced. Why is it that devoicing possible responses were so high in the experiment, across all the conditions?

This discrepancy may point to an important lesson about general methodology in phonological judgment experimentation. If the participants were asked whether some phonological
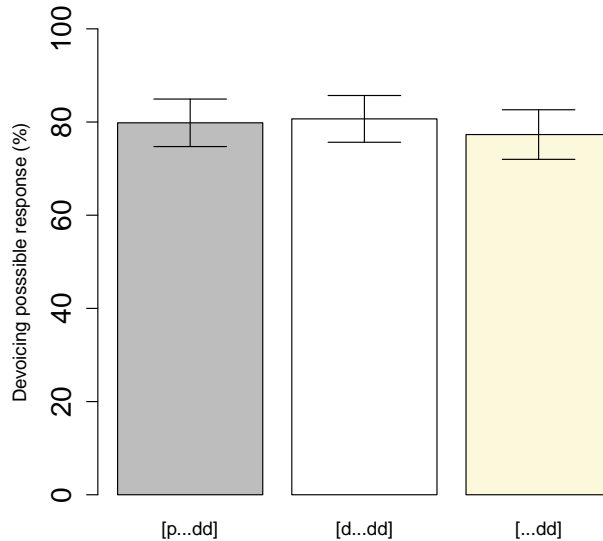
Figure 2: The proportions of devoicing possible responses for each condition: Nonce words.

pattern is *possible or not*, they may be inclined to be "more forgiving"—or more willing to accept a phonological change—than what they actually do in their actual speech behavior. This task effect may arise partly because speakers know that other speakers may do what they do not do themselves, possibly due to dialectal or speech style differences. The current participants may have thought that *some* speakers may devoice these geminates in the stimuli, even if they themselves would pronounce them as voiced.

In fact, this task effect of the possible vs. impossible judgment paradigm may not be new. Kawahara (2013) used the same methodology as Experiment I and asked the devoicability of singletons and geminates in Japanese. The results were that geminates in the "elsewhere" condition were judged to be devoicable 62% of the time, again higher than the corpus data presented above. Singletons were judged to be devoicable 34% of the time when there is another voiced obstruent, and 22% of the time when there is not. We do not have corpus data regarding how often singletons are devoiced in actual utterances, but these percentages seem unrealistically high (see the results of Experiment II). This issue of the task effect observed in Experiment I will be addressed in Experiment II by directly asking the participants what they actually do.

The results of nonce words, albeit being null results, may be informative as well. Although we should not make a conclusion based on null results, one possible explanation is that the /p/-driven devoicing is "phonologically too outlandish" that it may not be internalized as a

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productive process in the minds of Japanese speakers, and hence is not extended to nonce words (see Becker et al. 2011 and Hayes et al. 2009 for related discussion). This possibility is discussed in further depth in the general discussion section.

An alternative explanation for the results of the nonce word stimuli is possible. It is independently observed that, for some reason, differences between different grammatical conditions in phonological judgment experiments become smaller when the participants make a judgment about nonce words than when they make judgements about real words (Kawahara, 2010, 2013). Furthermore, responses become closer to a chance level for nonce words than for real words (Kawahara, 2010, 2013). These general characteristics of nonce words in phonological experimentation may have diminished the potential differences between the three conditions in the current experiment.

4 Experiment II: A forced-choice judgment task

In Experiment I, the participant judged devoicing of geminates to be possible much more frequently than what is observed in the corpus as well as our intuition-based expectations. As discussed above, this result may be due to a task effect by which the participants were more accommodating about a possible phonological process when asked if the process is possible or not. In order to address this possibility, Experiment II asked the participants to choose a form that they themselves actually use.

4.1 Method

4.1.1 Task

As with Experiment I, within each trial, the participants were given one word containing a geminate, but this time presented with two forms, one "faithful" rendition and the other "devoiced rendition". For example, they were asked: "given the word *kyuupiddo*, which pronunciation do you actually use, /kyuupiddo/ or /kyuupitto/?" This task can be considered as a "head-to-head" or "forced-choice" task in which the participants are presented with two forms, and are asked to choose one form that sounds more grammatical (see Daland et al. 2011 for the use of this paradigm in phonological experimentation).

In this paradigm, the participants may have been biased toward choosing the faithful form, because it is also given as a base form, and also because they may think that devoicing a geminate is "prescriptively not correct". However, the results showed that there were enough non-faithful, devoiced responses, as we will see below.

4.1.2 Stimuli

The current methodology cannot be used for nonce words, because the participants would not know how they actually pronounce words that do not exist. This restriction, however, allowed us to include more conditions than in Experiment I. Therefore, Experiment II included five conditions: (i) geminates appearing with /p/ (e.g. /paddo/), (ii) geminates appearing with another voiced obstruent (e.g. /baddo/), (iii) geminates without either /p/ or a voiced obstruent (e.g. /heddo/—the "elsewhere" condition above), (iv) voiced singletons appearing with another voiced singleton (e.g. /baado/), and (v) voiced singletons without another voiced singleton (e.g. /haado/).

The experimental items for the real words and nonce words are provided in Table 4.[5] The stimuli for the first three conditions were almost identical to that of Experiment I, except that those words with /gg/ were replaced with those with /dd/. By mistake, /gaado/ was included twice in the fourth condition, and the responses for the first occurrence of /gaado/ were excluded from the analysis.

Table 4: The stimuli for Experiment II.

/p...dd/		/b...dd/		/...dd/	
/kyuupiddo/	'cupid'	/baddo/	'bad'	/heddo/	'head'
/paddo/	'pad'	/beddo/	'bed'	/reddo/	'red'
/aipaddo/	'i-pad'	/deddo/	'dead'	/uddo/	'wood'
/aipoddo/	'i-pod'	/guddo/	'good'	/kiddo/	'kid'
/supureddo/	'spread'	/daddo/	'dad'	/maddo/	'mad'
/piramiddo/	'pyramid'	/goddo/	'god'	/roddo/	'rod'
/tetorapoddo/	'tetrapod'	/budda/	'Buddha'	/middo/	'mid'
		/d...d/		/....d/	
		/baraado/	'ballad'	/haado/	'hard'
		/baado/	'bird'	/raado/	'lard'
		/bideo/	'video'	/kaado/	'card'
		/gaado/	'guard'	/koodo/	'cord'
		/boodo/	'board'	/roodo/	'road'
		/gaaden/	'garden'	/saido/	'side'
				/huudo/	'hood'

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[5]Singleton consonants tend to be preceded by a long vowel or a diphthong because gemination is very common after a short vowel in the phase of loanword adaptation (Katayama, 1998; Kubozono et al., 2008).

4.1.3 Procedure and statistics

The procedure and the statistical analyses were identical to those of Experiment I.

4.1.4 Participants

Fifty native speakers of Japanese completed the online experiment. Experiment I was run in June-July 2013, and Experiment II was run in August 2014. Since the participants were invited partly through a social network service, there may be some overlap of the participants between the two experiments. However, since the two experiments were conducted more than a year apart, we expected little or no influences.

4.2 Results

Figure 3 shows the proportions of devoiced forms being selected, with error bars representing 95% binomial confidence intervals. We observe declining order of devoiced forms being selected from left to right (46.6%, 31.4%, 7.7%, 0.6%, 0%).
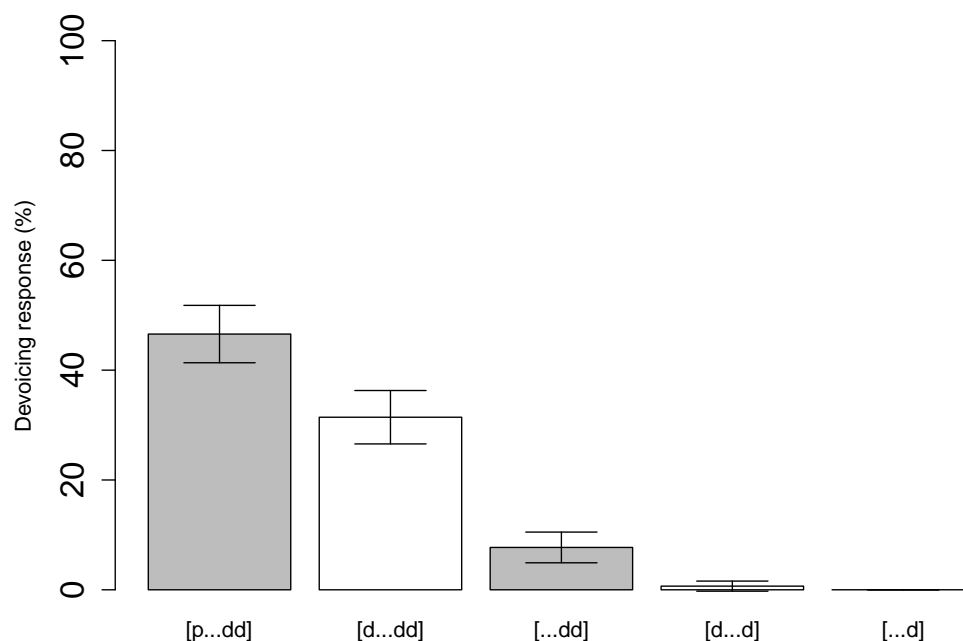

Figure 3: The proportions of devoicing responses for each condition.

Setting aside the singleton consonants, which showed few or no devoiced responses, a

linear mixed model comparing the first three conditions, all containing geminates, showed a significant effect ($z = 3.75, p < .001$). The difference between the first bar (the /p/-condition) and the third condition (the "elsewhere" condition) is significant ($z = 4.31, p < .001$); the difference between the first two conditions did not reach significance ($z = 1.83, n.s.$), although it is near significance ($p = .067$).

4.3   Discussion

First of all, the experimental results show that /p/ does cause devoicing of geminates, as much as—possibly more than—a voiced obstruent does. This result supports our initial intuition that words of the form /p...dd/ may be pronounced as /p...tt/ with fifty naive native speakers of Japanese. Although the same results were obtained in Experiment I for real words, the differences between the /p/ condition and the "elsewhere" condition were more pronounced in the current study.

Compared to Experiment I, the current experimental paradigm yielded values that are closer to those that are found in the corpus studies, at least for the /p/ condition and the "elsewhere" condition. Recall also that the participants did not choose devoiced singletons in Experiment II, while Kawahara (2013) found that in a possible vs. impossible format, singletons were judged to be devoicable about 20-30% of the time. Which experiment better reflects the true production of voiced singletons by Japanese speakers needs to be checked against actual production patterns, although we are inclined to say, admittedly based on our own intuition, that the current paradigm yielded results that are closer to what Japanese speakers actually do.

This task effect is perhaps not too surprising because the current experiment asked the participants about what they actually do. This result again highlights the importance of probing task effects in phonological experimentation. It may be the case that this type of methodology is better than the possible vs. impossible format deployed in Experiment I and Kawahara (2013), especially when we are interested in what the speakers actually do. However, this paradigm has a drawback of not being able to use nonce word stimuli.

Another point to be noted about this experimental paradigm is that this experiment was unexpectedly successful in that it elicited enough "non-faithful" responses. Given that the devoicing process is optional, there was a concern that the participants may not choose the devoiced options at all.[6] Recall that the participants were presented with a word A, and they were asked if they would pronounce it as A (faithful) or A' (non-faithful).[7] It would not

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[6]If the target phenomenon is a morphophonological process involving morpheme concatenation, then this paradigm is equivalent to a well-known wug-test in a forced choice format (Berko, 1958).

[7]A comparable question in English would be: "given a word like *west*, would you usually pronounce it as /west/ or /wes/?"

be surprising if all the participants would have chosen A throughout, especially if they think they should be "prescriptively correct". The experimental results show that the head-to-head methodology is possible when probing an optional process, because participants do choose unfaithful options. This methodology can and perhaps should be applied to other optional phonological processes, such as t/d-deletion in English (Coetzee & Pater, 2011; Coetzee & Kawahara, 2013; Guy, 1991).

5   General discussion

The corpus-based study as well as the judgement experiments have shown that /p/ does cause devoicing of geminates in Japanese loanwords. Although the focus of this paper is descriptive (i.e. to attempt to find objective evidence for /p/-driven devoicing), we briefly entertain possible ways of modeling this pattern theoretically. Overall, modeling the interaction between /p/ and voiced geminates is challenging, because /p/ and voiced geminates do not have anything in common, at least superficially. At least none of the theoretical analyses that are developed for devoicing of geminates due to another voiced obstruent predicts this /p/-driven devoicing (Coetzee & Kawahara, 2013; Coetzee & Pater, 2011; Farris-Trimble, 2008; Kawahara, 2006; Nishimura, 2003; Pater, 2009; Rice, 2006). This is because essentially all the analyses assume or posit that the cause of devoicing is OCP(voice), but /p/ should not induce a violation of OCP(voice).[8]

One possible analysis is to build on the observation that both singleton /p/'s and voiced geminates are allowed only in loanwords (Ito & Mester, 1995, 1999, 2008). In this sense, /p/ and voiced geminates share the property of being unfamiliar or non-frequent in the entire lexicon of Japanese. Fukazawa et al. (2014) show based on the lexical search of Amano & Kondo (1999) that /p/ and voiced geminates are the two most infrequent sounds in the whole Japanese lexicon. They argue that there may be a sort of OCP constraint, independent of OCP(voice), which prohibits the occurrence of two unfamiliar segments within a word; i.e. OCP(unfamiliar). This theory predicts that there should be other languages which prohibit a word that contains two sounds that are infrequent or two sounds that are found only in loanwords.

A related possibility is to posit a locally conjoined constraint (Smolensky 1993 *et seq.*), in the spirit of Nishimura (2003), like $\{*/p/\&*\text{VOICEOBSGEM}\}_{stem}$. However, this constraint seems nothing more than a restatement of the observation, and predicts that, cross-

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[8]Or should it? We could potentially postulate that /p/ and /b/ are both [+voice], and distinguish them in terms of [spread glottis], for example. As far as we know, there is no independent evidence that /p/ is [+voice] in Japanese, however. The fundamental problem here is that /p, b, d, g/ do not form a natural class for other phonological patterns in Japanese.

linguistically, two irrelevant markedness constraints can be conjoined with a domain as large as a stem. Allowing this sort of local conjunction would probably result in too much theoretical power (Kawahara, 2006; McCarthy, 2003; Pater, 2009, to appear).

A more radical alternative analysis is possible based on the Japanese orthography: voiced obstruents and /p/ are shown with diacritic marks on the upper right corner, the former with *dakuten* and the latter with *han-dakuten*, as illustrated by some examples in Figure 4.

$$\text{は} = /\text{ha}/$$
$$\text{ぱ} = /\text{pa}/$$
$$\text{ば} = /\text{ba}/$$

Figure 4: The Japanese orthography symbols for /ha/, /pa/, and /ba/. Those for /pa/ and /ba/ are shown with a diacritic mark on the upper right corner.

Therefore both /p/'s and voiced obstruents are written with an orthographic diacritic; in this sense, /p/ and voiced obstruents form a natural class. It may be the case then that OCP(voice) is actually OCP(diacritic), which accounts for both /p/-driven devoicing and OCP-driven devoicing at the same time. This analysis is radical in the sense that it shifts the burden of explanation from sounds to letters—a move that should be cautiously taken from the viewpoint of phonological theory (though see Ito et al. 1996 for a similar example of an orthography-based explanation of a phonological observation). This theory makes a specific prediction, namely in terms of the behavior of pre-literature children. To the extent that Lyman's Law or OCP(voice) is a matter of orthography, so as to target the configuration /p...dd/, then preliterate Japanese-speaking children should not show the evidence for Lyman's Law, or at least /p/-driven devoicing. In fact, Fukuda & Fukuda (1994) do find evidence to this effect—under-learning of Lyman's Law. A more targeted longitudinal experiment is called for to fully defend this prediction, however, especially to examine whether pre-literate children fail to show /p/-driven devoicing.

A final possible explanation is to say that /p/-driven devoicing occurs in existing loanwords, but this pattern is too "outlandish" as a phonological pattern so that it is not phonologized in the minds of the contemporary Japanese speakers (cf. Becker et al. 2011). This idea would capitalize on the null results of the nonce words in Experiment I. Although this analysis is not impossible, it does not explain why the existing words show evidence for /p/-driven devoicing. This devoicing pattern of geminates emerged spontaneously in the loanword phonology, because Japanese did not used to have voiced geminates in the native phonology. This theory thus fails to explain why /p/-driven devoicing emerged in the first

place. This theory also has a danger of relying on null results.

Since there are no knock-out arguments for one over the other, we remain neutral about the best explanation of the /p/-devoicing pattern in this paper. We reiterate that the value of this paper mostly lies in its new descriptive discovery, in addition to the new findings about task effects in phonological experimentation.

We will close this section by raising one final question, which may bear on the theoretical analyses: are /p/-driven devoicing and OCP-driven devoicing the same phonological pattern or are they different? The corpus study shows that OCP-driven devoicing is more common; neither conditions in Experiment I revealed differences between the two; Experiment II shows that /p/-driven devoicing tends to be more common, although the difference did not reach statistical significance. At this point, the evidence seems so mixed that this issue needs to be resolved in a future study.

6   Conclusion

The main goal of this paper was to objectively examine, beyond our own intuition, whether /p/ causes devoicing of geminates in Japanese loanword phonology. A corpus study as well as two judgment experiments show that /p/ does cause devoicing, at least in existing words. This new descriptive discovery poses a challenge to the theoretical analysis of geminate devoicing patterns in Japanese phonology in general.

In addition to this new descriptive discovery, we found non-trivial task effects in phonological experimentation. Experiment I shows that when the participants were asked if a phonological process is possible or not, they may be more inclined to say yes, perhaps more than they actually do. Experiment II shows that it is possible to ask what they do in their phonological behavior of an optional phonological process.

All in all, it seems safe to conclude that /p/, just like voiced obstruents, causes devoicing of geminates in Japanese. We look forward to seeing future theoretical analyses developed to account for these devoicing patterns.

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