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Emphatic gemination in Japanese mimetic words: a wug-test with auditory stimuli

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ABSTRACT

Building on Nasu (1999), this paper reports an auditory judgment study of emphatic gemination in Japanese mimetic words. The study replicates Nasu's results that given C1VC2V–C3VC4V mimetic words, speakers by default target C2 for gemination, but that they can also geminate C3 if geminating C2 would result in a marked geminate. The experiment further reveals that Japanese speakers prefer stop geminates the most, fricative geminates less, and nasal geminates the least. This finding shows that speakers have differential preferences between the structures that exist in their language, supporting a growing body of experimental studies demonstrating that native speakers do not treat all attested structures alike.

1. Introduction

1.1. Synopsis

Building on Nasu (1999), this paper reports an auditory wug-test of emphatic gemination in Japanese mimetic phonology. The pattern of emphatic gemination in Japanese mimetic words has not received much systematic attention in the literature, with a notable exception of Nasu (1999). Therefore the discussion below is largely descriptive, although this paper will discuss various analyses of the experimental results from different perspectives. The study replicates Nasu's (1999) previous results that given C1VC2V–C3VC4V mimetic words, Japanese speakers by default target C2 for gemination, but they can also geminate C3 if geminating C2 would result in a marked geminate. The experiment further reveals that Japanese speakers prefer stop geminates the most, fricative geminates less, and nasal geminates the least.

One contribution that this study makes to current theoretical debates is to show that speakers have differential preferences between the structures that exist in their language. That is, speakers do not simply make a grammatical/ungrammatical dichotomy, as was assumed in the most generative literature. Rather, speakers assign different degrees of grammaticality to different structures in their language, as a growing body of recent experimental studies shows (Albright, 2009; Albright and Hayes, 2003; Coetzee, 2008, 2009; Coleman and Pierrehumbert, 1997; Fanselow et al., 2006; Frisch et al., 2000, 2004; Hay et al., 2003; Hayes and Londe, 2006; Hayes, 2009; Hayes et al., 2009; Kawahara and Kao, 2012; Pierrehumbert, 2001; Zuraw, 2000, 2010; see Pierrehumbert (2001) for a summary). Cast in a current phonological parlance, we can say that a

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structure [A] can be "more marked" than [B], even when speakers allow both [A] and [B] in their language. The notion of "markedness" covers many different (but often mutually related) notions[1]—this paper uses the term "markedness" to simply mean an observed preferential hierarchy among a set of phonological structures.

1.2. Previous studies on emphatic gemination in Japanese

Several authors have noticed that Japanese uses gemination to express emphasis.[2] For example, Aizawa (1985), Bruch (1986) and Tamori (1991) note that gemination expresses emphasis in Japanese (mimetic) words. In a comprehensive study of mimetic words, Hamano (1986) discusses a productive gemination process in mimetic and non-mimetic forms (pp. 35–36, 107–108, page references to the published version). Vance (1987, pp. 42–43) and Kawahara (2001) discuss a general process of emphatic gemination applying to even non-mimetic words. This process of emphatic gemination, they observe, can create kinds of geminates that are otherwise non-contrastive in Japanese (e.g. voiced obstruent geminates in native words and approximant geminates).

Among other studies, Nasu (1999) presents by far the most systematic study of emphatic gemination in Japanese mimetic words. In a written questionnaire-based study, he asked 91 Japanese speakers to choose the appropriate gemination locus for the emphatic forms of real words; some of his example words are given in (1). In words like (1), the participants on average chose C2-gemination 83% of the time, C3-gemination only 17% of the time, and C4-gemination less than 1% of the time. Nasu (1999) attributes this general preference toward C2-gemination to a markedness constraint that favors initial heavy–light syllable sequences in Japanese, suggesting that markedness is an important factor that is responsible for this pattern (see Kubozono (2003) and Nasu (2005) for subsequent analyses).[3]

(1) Emphatic forms are created by C2-gemination by default (Nasu, 1999)

pika-pika	pikka-pika	?pikap-pika	*pika-pikka	'shiny'
teka-teka	tekka-teka	?tekat-teka	*teka-tekka	'glistening'

While Japanese speakers generally prefer C2-gemination, Nasu (1999) also shows that when C2 is a voiced obstruent and C3 is a voiceless obstruent, the possibility of C3-gemination increases. In words like (2) in which C2 is a voiced obstruent, his participants chose C3-gemination 51% of the time.

(2) The possibility of C3-gemination increases when C2 is a voiced obstruent (Nasu, 1999)

keba-keba	kebba-keba or kebak-keba	'too much make-up'
sube-sube	subbe-sube or subes-sube	'smooth'

The increased likelihood of C3-gemination in (2) is due to a dispreference against a voiced stop geminate, which is observed in Japanese as well as in many other languages.[4] Japanese does not allow voiced stop geminates in native words (except for those created by emphatic gemination, as in (2)), although Japanese does allow voiced stop geminates in loanwords (Itô and Mester, 1995, 1999; Katayama, 1998; Kawahara, 2006; Kubozono et al., 2008).

The shift of the gemination locus to C3 in (2) thus shows that C3-gemination can take place when it allows speakers to avoid certain types of geminates. In other words, the likelihood of C3-gemination reflects the low geminability of C2, i.e., the markedness of C2-geminates, as Nasu (1999) observes. Because of this characteristic, mimetic gemination provides a testing ground for revealing the geminability of different consonant types in Japanese phonology.

Building on Nasu's (1999) results, this study investigated whether manner of articulation has any systematic influence on the choice of emphatic geminates. Japanese lexically contrasts singletons and geminates for stops, fricatives, and nasals, but not approximants, as in (3) (Kawahara, in press). The question addressed in this study is thus whether Japanese speakers would distinguish these types of consonants in terms of their geminability. This question is interesting to address, because if it turned out that Japanese speakers do distinguish these types of geminates, the result shows that speakers' grammatical judgments are not a simple dichotomy between "grammatical" and "ungrammatical", supporting the recent experimental observation cited above at the end of Section 1.1.

[1] It is impossible to cover all the references on markedness here, but some major contributions would include the following: Archangeli and Pulleyblank (1994), Chomsky and Halle (1968), Jakobson (1941), Kean (1975), McCarthy and Prince (1994), Prince and Smolensky (1993/2004), and Trubetzkoy (1939). See also Haspelmath (2006), McCarthy (2002) and Rice (2007) for recent summaries and discussion.

[2] Languages often use gemination to express emphasis: e.g. Rotuman (Churchward, 1940) and Swahili (Lodhi, 2004); see Blevins (2004, p. 174) for other cases.

[3] An alternative analysis would be to say that the preference toward C2-gemination comes from a constraint requiring a heavy syllable to be in word-initial syllables (Zoll, 1998).

[4] This dispreference is likely to have its roots in the aerodynamic difficulty of implementing voicing in long geminate closure. With oral stop closure, intraoral air pressure rises, which makes it difficult to maintain the transglottal air pressure drop necessary to keep voicing (Hayes, 1999; Hayes and Steriade, 2004; Jaeger, 1978; Kawahara, 2006; Ohala, 1983; Westbury and Keating, 1986; Westbury, 1979, among others).

Table 1
The list of stimuli.

k-stems			p-stems		
C2 = stop	C2 = fricative	C2 = nasal	C2 = stop	C2 = fricative	C2 = nasal
kate-kate	kaso-kaso	kano-kano	pate-pate	pase-pase	pane-pane
kato-kato	kase-kase	kina-kina	pato-pato	pise-pise	pano-pano
kite-kite	kise-kise	kine-kine	pite-pite	piso-piso	pine-pine
kute-kute	kiso-kiso	kino-kino	puta-puta	pusa-pusa	puna-puna
kuto-kuto	kesa-kesa	kuno-kuno	pute-pute	puse-puse	puno-puno
kete-kete	kese-kese	kena-kena	puto-puto	puso-puso	pena-pena
keto-keto	keso-keso	kene-kene	pete-pete	pese-pese	peno-peno
kota-kota	kosa-kosa	keno-keno	pito-pito	pose-pose	pone-pone

(3) Lexical singleton/geminate contrasts in Japanese

kata	'frame'	katta	'bought'
iso	'shore'	isso	'then'
kona	'powder'	konna	'such'

Although this study heavily draws on Nasu's (1999) study, it departs from Nasu's (1999) original study in three respects. First, his study aimed to compare a difference between the geminability of voiced obstruents and that of voiceless obstruents, but this study compared a differential geminability preference hierarchy between stops, fricatives, and nasals. Second, while Nasu's (1999) original study was paper-based, this study deployed an auditory judgment method to avoid any effects of orthography in grammatical judgments. Third, Nasu (1999) used real words in his experiment, but this study instead used nonce words to test the true productivity of the gemination pattern.

2. Method

2.1. Stimuli

This experiment had the following stimulus design. To avoid any influence of orthography, the experiment used auditory stimuli. The stimuli were C1V1C2V2–C3V3C4V4 nonce reduplicative mimetic words (e.g. *kate-kate*). The experiment used nonce words to test the true productivity of mimetic gemination (i.e. a wug-test: Berko, 1958). Among those consonants that have lexical singleton–geminate contrasts (see (3)), to compare different manners of articulation in C2 while controlling for place, coronal consonants [t, s, n] were used for C2, since Japanese has no phonemic labial or dorsal fricatives (it remains to be seen whether the pattern obtained below holds for segments at other places of articulation).[5] Voiced obstruents were excluded since their behavior had already been investigated by Nasu (1999). The choice of coronal consonants in C2 requires that V2 must be non-high because high vowels cause affrication of [t]. Each type of C2 was paired up with two types of C3, [p] and [k]. In order to make all the stimuli nonce-words, this study could not control for the quality of all the vowels.[6] As a result of these considerations, each condition contained 8 items. The whole list of stimuli is provided in Table 1.

In addition, the stimuli included filler stimuli using [b] and [g] in C3, listed in Table 2. The study included these fillers since the target stimuli contain only voiceless consonants in C2 and C3.

2.2. Recording

A female native speaker of Japanese read the list of words in the following frame sentence: *jaa* __ *de* 'please do something with __'.[7] For each stimulus, three types of form—a form with no gemination, a form with C2-gemination, and a form with C3-gemination—were written on a separate index card with the Japanese katakana orthography, and presented to the speaker. The

[5] A traditional analysis of geminates in Japanese posits two different representations: /Q/ (*sokuon*) for obstruent geminates and /N/ (*hatsuon*) for nasal geminates (Vance, 1987). However, this paper assumes that they are both phonologically represented as moraic consonants (Hayes, 1989), because obstruent geminates and nasal geminates can pattern together in Japanese phonology. First, both obstruent and nasal geminates make the preceding syllable heavy, which is expected if they are represented with an additional mora (Hayes, 1989). Second, a prefix [ma-] causes gemination of root-initial consonants, as in *mat-taira* 'very flat', *mas-sakasama* 'upside down', and *mam-maru* 'truely round' (see (4)), and this gemination targets all of stops, fricatives, and nasals. If we represent gemination with an additional mora, we can account for this patterning of [ma-] by positing an underlyingly floating mora with /ma-/, whereas if we take the traditional view, we would be forced to assume that [ma-] is underlyingly /maN/ or /maQ/, a disjunctive statement which is to be avoided.

[6] Although high vowels devoice between voiceless consonants (Tsuchida, 1997 and references cited therein), I could not exclude high V1 from the stimulus set because otherwise, with other non-avoidable restrictions, not enough nonce forms would exist for each condition.

[7] It may have been desirable to use [h], instead of [d], for the consonant following the target stimuli to exclude VC formant transition information at the end of target words, but none of the Japanese post-nominal particles begin with [h]. After the stimuli were extracted from the frame sentence, some native speakers of Japanese listened to the stimuli, and none of them had a coronal percept in the last vowel of the stimuli. Some consultants reported perceiving a glottal stop, but this percept was not expected to cause a problem because a word-final short vowel in Japanese is typically followed by a glottal stop (0370protectVance, 1987, pp. 12–13).

Table 2
The list of fillers.

b-stems			g-stems		
C2 = stop	C2 = fricative	C2 = nasal	C2 = stop	C2 = fricative	C2 = nasal
bato-bato	base-base	bunu-bunu	gate-gate	gaso-gaso	ganu-ganu
bita-bita	baso-baso	beno-beno	gato-gato	gisa-gisa	gano-gano
bitu-bitu	bisa-bisa	bonu-bonu	gite-gite	gise-gise	gina-gina
bite-bite	bise-bise	bena-bena	gute-gute	giso-giso	gine-gine
bito-bito	busa-busa	bana-bana	guto-guto	guse-guse	guna-guna
bute-bute	buso-buso	banu-banu	gitu-gitu	gesa-gesa	gunu-gunu
buto-buto	besa-besa	binu-binu	gete-gete	gose-gose	genu-genu
bete-bete	bose-bose	bino-bino	geto-geto	gese-gese	goni-goni

Table 3
Average durational properties of the recorded tokens in ms (based on six repetitions). The values in the parentheses represent standard errors.

	V1 duration	C2 duration	V2 duration	C3 duration
C2 = [tt], C3 = [k]	57 (1.7)	142 (2.1)	53 (0.9)	51 (1.0)
C2 = [t], C3 = [kk]	37 (1.4)	65 (1.1)	83 (1.2)	149 (2.1)
C2 = [ss], C3 = [k] (V1 = non-high)	74 (1.3)	133 (1.6)	52 (1.0)	58 (1.3)
C2 = [s], C3 = [kk] (V1 = non-high)	53 (1.6)	84 (0.9)	76 (1.5)	124 (2.1)
C2 = [nn], C3 = [k]	77 (2.0)	98 (1.6)	71 (0.9)	54 (0.8)
C2 = [n], C3 = [kk]	48 (2.5)	53 (2.0)	108 (1.3)	138 (1.8)
		V1 + C2 duration	V2 duration	C3 duration
C2 = [ss], C3 = [k] (V1 = high)		219 (6.2)	48 (1.7)	61 (2.5)
C2 = [s], C3 = [kk] (V1 = high)		134 (2.4)	78 (2.4)	135 (4.1)
	V1 duration	C2 duration	V2 duration	C3 duration
C2 = [tt], C3 = [p]	65 (2.2)	146 (2.4)	51 (1.3)	63 (1.3)
C2 = [t], C3 = [pp]	52 (1.5)	66 (1.3)	82 (1.0)	131(2.2)
C2 = [ss], C3 = [p] (V1 = non-high)	78 (2.0)	134 (3.2)	45 (2.2)	66 (2.2)
C2 = [s], C3 = [pp] (V1 = non-high)	60 (2.3)	83 (1.5)	71 (2.2)	133 (3.3)
C2 = [nn], C3 = [p]	83 (1.9)	96 (1.6)	65 (1.0)	69 (1.1)
C2 = [n], C3 = [pp]	48 (2.1)	43 (1.0)	97 (1.2)	149 (1.7)
		V1 + C2 duration	V2 duration	C3 duration
C2 = [ss], C3 = [p] (V1 = high)		224 (3.1)	47 (1.5)	68 (1.5)
C2 = [s], C3 = [pp] (V1 = high)		134 (2.3)	79 (1.4)	143 (2.2)

experiment did not include forms with C4-gemination, because 0305protectNasu, 1999) participants barely chose forms with C4-gemination. In pronouncing the stimuli, the speaker was told that the words were quasi-Japanese mimetic words. She was asked to pronounce the nonce words in a natural speech style using unaccented pitch contour. The target stimuli were read six times in order to obtain representative tokens of each stimulus. The fillers were read only twice, because the quality of the filler stimuli was not of great importance. The order of the stimuli was randomized between each repetition. The recording session took place in a sound-proof booth. The speech was recorded through a microphone (MicroMic II C420) to a Macintosh computer at 44.100 kHz sampling rate and 16 bit quantization level. The recording session lasted about 70 min including short breaks between repetitions.

2.3. Construction of the auditory stimuli

First, in order to choose representative tokens for each item, durational properties of recorded tokens were measured. In measuring durations, segmental boundaries were placed between vowels and consonants based on the onset and offset of F2 and F3. Table 3 shows the average durations of V1, C2, V2 and C3 for each item type; when V1 = high and C2 = fricative, V1 devoices and spectrally assimilates to the following fricative, so the summed V1 + C2 durations are reported instead of the individual durations of V1 and C2.[8]

To choose a representative token of each stimulus, various criterion measures were possible: absolute constriction duration of geminates, V1/C1 ratios, and geminate/singleton duration ratios (C2/C3 for C2-gemination stimuli, and C3/C2 for C3-gemination stimuli). Among these, geminate/singleton duration ratios were used, because these ratios directly compare the

[8] In Japanese, vowels are longer before geminates than before singletons, despite the fact that in many languages vowels are shorter in closed syllables than in open syllables (Maddieson, 1985). The pre-geminate lengthening of vowels in Japanese phonetics is a well-established observation (see Section 4.3 for references), and perhaps not even a typological anomaly; see Kawahara (in press) for discussion.

Table 4
Geminate/singleton duration ratios and (VPre-Gem + CGem)/(VPre-Sing + CSing) ratios of the tokens used as the stimuli. Values in the second column represent standard errors.

C2, C3 combinations	Ratios	Standard errors
C2 = [tt], C3 = [k]	2.82	.06
C2 = [t], C3 = [kk]	2.16	.04
C2 = [ss], C3 = [k] (V1 = non-high)	2.31	.08
C2 = [ss], C3 = [k] (V1 = high)	2.24	.09
C2 = [s], C3 = [kk] (V1 = non-high)	1.44	.03
C2 = [s], C3 = [kk] (V1 = high)	1.55	.09
C2 = [nn], C3 = [k]	1.80	.03
C2 = [n], C3 = [kk]	2.76	.10
C2 = [tt], C3 = [p]	2.31	.04
C2 = [t], C3 = [pp]	2.04	.05
C2 = [ss], C3 = [p] (V1 = non-high)	2.05	.08
C2 = [ss], C3 = [p] (V1 = high)	1.98	.05
C2 = [s], C3 = [pp] (V1 = non-high)	1.60	.04
C2 = [s], C3 = [pp] (V1 = high)	1.62	.04
C2 = [nn], C3 = [p]	1.41	.05
C2 = [n], C3 = [pp]	3.52	.03

duration of C2 and C3, which correspond to the participants' task of evaluating C2-gemination and C3-gemination. V1/C1 ratio was not used because V1 was devoiced in some conditions. Absolute duration of geminates was not used because it does not control for speech rate of each stimulus.

Geminate/singleton duration ratios were impossible to calculate when V1 = high and C2 = fricative, because V1 devoices and spectrally assimilates to the following fricative. For this case, (VPre-Gem + CGem)/(VPre-Sing + CSing) ratios were calculated instead. From the tokens for each type of stimulus, excluding ones that show phonetic irregularities (creakiness, clipping, non-high devoiced vowels, unnatural F0 contour), one token that had the closest measure to the mean of that group was chosen. Table 4 lists the relevant measures of those tokens that were used in the auditory experiment.

Target words were extracted from the frame sentence. The average amplitude of all the stimuli was scaled to be 75 dB across the stimuli, using Praat (Boersma, 2001; Boersma and Weenink, 1999–2013).

2.4. Experimental setup

To control for any preference that the participants might have toward the geminated form that is presented first or second, two group conditions were prepared. For each stimulus, in one condition the form with C2-gemination was presented first, and in the other condition the form with C3-gemination was presented first.

2.5. Participants

Twenty-four native speakers of Japanese participated in the experiment. They received 6 dollars for their time; one participant instead received extra credit for a linguistics class. None reported any speech or hearing disorders. Four participants pressed undesignated buttons, so their data was excluded from the analysis below.

2.6. Experimental procedure

The task of the experiment was to, given two choices, choose the more appropriate emphatic form of each stimulus. The experiment took place in a sound attenuated booth. Each participant sat at a desktop PC. Cedrus SuperLab Pro software presented all sound stimuli and visual prompts. Participants used Cedrus RB-834 response boxes to enter their responses. Each test trial had the following structure: a basic form of one mimetic form without gemination was played first, and after an interval of one second, two forms with gemination at different loci were played, separated by a 550 ms silence interval. When the sound finished playing, two color-coded visual prompts A and B appeared on the screen. Listeners indicated which form they preferred by pressing the appropriate button—A if they preferred the first form and B if they preferred the second form. The letters A and B were used to exclude any influence of Japanese orthography. The inter-trial interval was 750 ms. Listeners started with a training block, which presented six randomly selected filler stimuli. The participants had a chance to ask questions after the training session. The main session presented each of the 96 stimuli once. The order of the presentation was automatically randomized by Superlab. Listeners had a short break twice during the main session. The overall experiment took about 30 min, including the pre-experimental briefing and post-experimental debriefing.

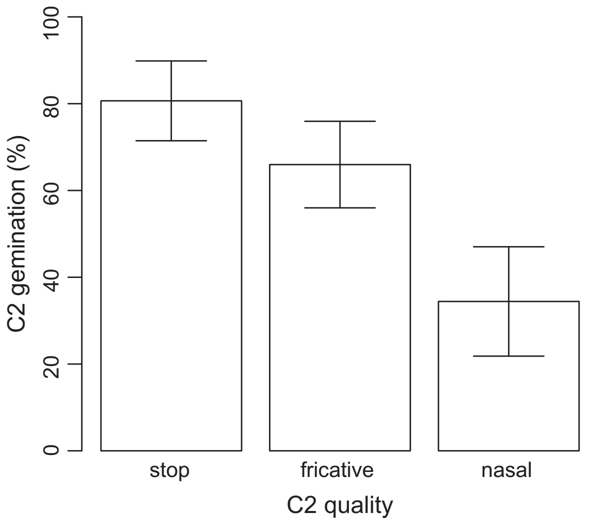

Fig. 1. The average C2 response percentages for each condition with 95% confidence intervals across all the participants. See Section 3.2 for the discussion of inter-speaker variability.

Table 5
A logistic regression analysis.

	β	exp(β)	Wald statistic	*p*
Order	.36	1.44	6.24	<.05
C2			54	<.001
Stop vs. Fric	1.01	2.76	15.71	<.001
Fric vs. Nas	.87	2.39	14.35	<.001
C3	−.12	.89	.62	*n.s.*
C2 × C3			7.47	<.05
Stop vs. Fric × C3	−.51	.60	1.91	*n.s.*
Fric vs. Nas × C3	.92	2.52	7.45	<.01

3. Results

3.1. General patterns

Fig. 1 illustrates the general results, showing the average C2 response percentages for each C2 consonant type with 95% confidence intervals, calculated across all 20 participants.

On average, Japanese speakers chose C2-gemination most often when C2 is a stop (80.7%), less when C2 is a fricative (66.0%), and the least often when C2 is a nasal (34.4%). Since the responses were based on a categorical decision (C2 or C3), logistic regression was run to analyze the data. The dependent variable was the response (either C2 or C3). The independent variables were the qualities of C2 (with contrast analyses comparing stops vs. fricatives and fricatives vs. nasals), the quality of C3, the interaction between C2 and C3, and the order (the two orders in which the stimuli were presented).[9]

Table 5 shows the results of this analysis. Both order and C2 had a significant impact on the choice of C2-gemination. Order was significant ($p < .05$) because the participants in the second order generally chose more C2-gemination than the participants in the first order (307 items vs. 272 items in total). More importantly, the quality of C2 had a significant effect, and contrast analyses on C2 reveals that both the difference between stops and fricatives, and the difference between fricatives and nasals were significant (both $p < .001$). C3 did not have a significant effect *per se*, but it significantly interacted with the nasal vs. fricative contrast ($p < .01$), because when C2 is a fricative, [p] in C3 induced more C2-gemination (116 items) than [k] (95 items), but when C2 is a nasal, [k] in C3 induced more C2-gemination (61 items) than [p] (49 items).[10]

Participants chose C2-gemination most of the time when C2 is a stop (80.7%). In other words, when C2 and C3 are both voiceless stops, speakers preferred C2-gemination, replicating Nasu's (1999) original study with auditory stimuli. However, when C2 is a fricative and C3 is a stop, speakers preferred C2-gemination less often than when C2 is a stop (66.0%). This pattern

[9] To avoid interpreting complex interaction terms, the analysis did not include other interaction terms in the regression model.
[10] A good explanation of this complex interaction is yet to be investigated.

Table 6
Inter-speaker variability and consistency.

Participant	Stop (%)	Fricative (%)	Nasal (%)
A. Dominantly C2-gemination in all condition			
1.	87.5	81.3	75.0
18.	93.8	93.8	93.8
B. C2-gemination if stop or fricative, C3-gemination if nasal			
17.	81.3	87.5	25.0
19.	81.3	75.0	25.0
C. C2-gemination if stop, variable if fricative, C3-gemination if nasal			
2.	93.8	50.0	6.7
10.	93.8	75.0	12.5
13.	93.8	62.5	12.5
15.	93.8	56.3	0
D. C2-gemination if stop, variable if fricative and nasal			
16.	93.8	68.8	56.3
E. C2-gemination if stop and fricative, variable if nasal			
11.	100	93.8	56.3
F. Dominantly C3-gemination			
4.	31.3	18.8	6.3
8.	37.5	37.5	6.3
G. Less prototypical patterns			
3.	68.8	81.3	25.0
5.	87.5	81.3	62.5
6.	100	87.5	68.8
7.	68.8	31.3	6.3
9.	87.5	43.8	31.3
12.	62.5	62.5	43.8
14.	62.5	56.3	37.5
20.	93.8	75	37.5

is almost uniformly observed across the speakers: only two participants showed more C2-gemination when C2 is a fricative than when it is a stop. One participant chose 11 stop gemination tokens in C2 and 13 fricative gemination tokens in C2. The other participant chose 13 stop gemination tokens in C2 and 14 fricative gemination tokens in C2. These reversals are small in magnitude. It is likely that these participants accept C2 geminate stops and C2 geminate fricatives equally well (see Section 3.2), but due to some experimental uncertainty, they chose geminate fricatives slightly more often than geminate stops. It seems safe to make this conclusion because the rest of the 18 participants chose more—or equal numbers of—C2 geminate stops than geminate fricatives. Summarizing so far, C2-gemination is the default position for gemination, and the participants sometimes moved the gemination loci to avoid geminate fricatives overriding the default C2-gemination pattern.[11]

The difference between geminate fricatives and geminate nasals is uniform across all the participants. All the 20 participants more readily shifted gemination loci to avoid geminate nasals (C2 nasal gemination = 34.4%) than to avoid geminate fricatives (C2 fricative gemination = 65.9%). In summary, when speakers create emphatic forms, they prefer geminate stops the most, geminate fricatives next, and geminate nasals least.

3.2. Interspeaker variability and consistency

Having analyzed general patterns, we now turn to individual patterns. The C2-geminate percentages for each type of C2 are shown in Table 6 for each participant. For the sake of classification, if participants gave responses between 33.4% and 66.8%, their choice between C2- and C3-gemination was assumed to be variable.

Two participants (more or less) consistently chose C2-gemination regardless of C2's quality (Pattern A). A few participants preferred C2-gemination when C2 is a stop or a fricative, but resorted to C3-gemination when C2 is a nasal (Pattern B). Some other patterns involved less categorical judgments for some C2-types. For example, many speakers chose C2-gemination if C2 was a stop, variably chose C2 and C3-gemination if C2 was a fricative, and chose C3-gemination if C2 was a nasal (Pattern C). Also, one listener showed variability when C2 is a fricative or a nasal, but not when C2 is a stop (Pattern D). Similar to Pattern D, one participant chose C2-gemination consistently if it was a stop or a fricative, but variably if it was a nasal (Pattern E). Finally, two participants preferred C3-gemination in general. These exceptional participants may have favored C3-gemination over C2-gemination because of a preference to put a floating mora at an morpheme edge (McCarthy and Prince, 1993). Nevertheless, these participants preferred C2 nasal geminates the least, geminate fricatives next, and geminate stops the most.

[11] The avoidance of fricative geminates is observed in Nasu's (1999) data as well: the real words that have C2 stops induced more C2-gemination (*pika-pika*: 99%, *teka-teka*: 81%, *kuta-kuta*: 91%) than those that have C2 fricatives (*pasa-pasa*: 69%, *kasa-kasa*: 65%).

To summarize, all speakers show the preference hierarchy: stop geminates ≻ fricative geminates ≻ nasal geminates (where A ≻ B indicates that A is "more harmonic than B", which in turn indicates that "B is more marked than A": Prince and Smolensky, 1993/2004). They however differ in the degree of general preference toward C2-gemination. One remaining question is where the different patterns come from, but it is beyond the scope of this paper to explore the source of this inter-speaker variability. Nevertheless, despite this variability, all speakers show the same preferential hierarchy for emphatic geminates.

4. General discussion

4.1. Differential preferences among different types of geminates

The experiment reported above shows that Japanese speakers show the preferential hierarchy—stop geminates ≻ fricative geminates ≻ nasal geminates—even though Japanese phonology allows all these kinds of geminates to make lexical contrasts. Moreover, other phonological patterns in Japanese can treat all these kinds of geminates alike. For example, the prefix *ma*- causes gemination of root-initial consonants regardless of manner, as in (4) (Martin, 1952). The same is true with gemination caused by *-ri*, as in (5) (Kuroda, 1965). The current experimental finding thus shows that speakers have differential preferences between the structures that exist in their language, even when there are other phonological processes that do not make such distinctions. The question that arises is thus where the preferential hierarchy comes from. We now turn to some possible answers to this question.

(4) Gemination by [ma-] targets stops, fricatives, and nasals

taira	ma**t-t**aira	'truly flat'
kur	ma**k-k**uro	'truly black'
sugu	ma**s-s**ugu	'truly straight'
sakasama	ma**s-s**akasama	'truly upside down'
naka	ma**n-n**aka	'truly middle'
maru	ma**m-m**aru	'truly round'

(5) Gemination by [-ri] targets stops, fricatives, and nasals

uka	u**kk**a-ri	'absentmindedly'
uto	u**tt**o-ri	'infatuated'
hiso	hi**ss**o-ri	'secretly'
koso	ko**ss**o-ri	'behind one's back'
hono	ho**nn**o-ri	'dimly, faintly'
ʃina	ʃi**nn**a-ri	'withered'

4.2. An explanation based on perceptibility differences

One possible basis for the preferential hierarchy (stop geminates ≻ fricative geminates ≻ nasal geminates) comes from a cross-linguistically motivated markedness hierarchy, which is arguably grounded in phonetics. Starting with nasal geminates, many languages lack sonorant geminates or avoid creating them (Kawahara et al., 2011; Kawahara, 2012; Podesva, 2000, 2002); e.g. Berber (Elmedlaoui, 1995, pp. 194–195) and Ilokano (Hayes, 1989, p. 270). Podesva (2000, 2002) proposes that the markedness hierarchy of geminate sonorant consonants is grounded in the phonetic imperative to keep contrastive sounds perceptually distinct, following the general spirit of Adaptive Dispersion Theory (Liljencrants and Lindblom, 1972; Lindblom, 1986 *et seq.*). The hypothesis is that confusion is more likely for sonorant singleton–geminate minimal pairs than for obstruent singleton–geminate minimal pairs. Since the segmental boundaries of sonorants are spectrally not clear-cut, their beginnings and ends are difficult to perceive. The perceptual indistinctiveness of segmental onset and offset leads to unclear perception of constriction duration for sonorant segments (see also Kato et al., 1997). Since singleton–geminate contrasts most crucially rely on constriction duration differences (Hankamer et al., 1989; Lahiri and Hankamer, 1988), the contrasts are difficult to perceive for sonorant segments than for obstruent segments (Kawahara et al., 2011; Kawahara, 2012; Podesva, 2000, 2002). In short, geminate sonorants are more marked than obstruent geminates, because sonorant singleton–geminate minimal pairs are perceptually difficult to distinguish.

Next, geminate fricatives are also cross-linguistically more marked than geminate stops. Geminate fricatives can occlusivize to geminate stops, as in dialects of Berber (Elmedlaoui, 1993; Saib, 1976), Fula (Paradis, 1992), and Wolof (Ka, 1994), whereas no reported languages spirantize geminate stops (Elmedlaoui, 1993; Kirchner, 1998). Moreover, Taylor

(1985, p. 143) notes, based on her survey of 28 languages, that "there are no languages with geminate fricatives but no geminate stops".

As is the case for geminate sonorants, the markedness of geminate fricatives may have its roots in the perceptibility of a singleton–geminate contrast. Although fricatives involve clear-cut segmental boundaries and therefore their constriction durations are not hard to perceive, geminate/singleton duration ratios are usually smaller for fricatives than for stops. Fricatives show small geminate/singleton ratios because singleton fricatives are longer than singleton stops (Lehiste, 1970), but geminate fricatives are only slightly longer than geminate stops. This generalization holds across many languages including Bernese German (Ham, 2001), Buginese (Cohn et al., 1999), Chikasaw (Gordon et al., 2000), Guinaang Bontok (Aoyama and Reid, 2006), Madurese (Cohn et al., 1999), and Toba Batak (Cohn et al., 1999).

Kawahara (in press) reports production data from three female Japanese speakers which show the same tendency in Japanese as well.[12] Given that geminate/singleton duration ratios are smaller for fricatives than for stops, singleton–geminate contrasts are perceptually less distinct for fricatives than for stops, as constriction duration differences constitute the primary cue to singleton–geminate distinctions. In short, geminate fricatives may be more marked than geminate stops because the singleton–geminate differences are harder to hear for fricatives than for stops. It is also possible that fricative geminates involve more articulatory effort than stop geminates (Kirchner, 1998).

In sum, cross-linguistic observations show that fricative geminates and nasal geminates are dispreferred, possibly for reasons that make phonetic sense: a singleton–geminate contrast is most perceptible for stops, less for fricatives, and least perceptible for nasals. Then, if Japanese speakers possess this phonetic knowledge (Kingston and Diehl, 1994) about the perceptibility scale of singleton–geminate contrasts, they may apply that knowledge when they create the mimetic gemination pattern and prefer those kinds of geminates that are distinct from their corresponding singletons.

4.3. Inferences from the phonetics of the stimuli

Another related explanation is that speakers noticed subtle phonetic differences in the stimuli—in Table 3, we observe that in terms of average C2 duration, nasal geminates are shortest (98 ms, 96 ms), and fricative geminates are longer (133 ms, 134 ms) than nasal geminates but shorter than stop geminates (142 ms, 146 ms). The participants in this study may have noticed these phonetic differences, and decided that phonetically longer segments are more compatible with emphatic meaning associated with gemination, assuming that speakers can notice subtle phonetic differences during the experiment and deploy those differences in a phonological judgment study.

One potential problem of this explanation, however, is that the preceding vowels are generally longer before geminates in Japanese (Campbell, 1999; Fukui, 1978; Han, 1994; Hirata, 2007; Hirose and Ashby, 2007; Idemaru and Guion, 2008; Kawahara, 2006; Ofuka, 2003; Port et al., 1987; Takeyasu, 2012), and that phonetically longer vowels generally bias listeners toward hearing long consonants (Arai and Kawagoe, 1998; Kingston et al., 2009; Ofuka, 2003; Ofuka et al., 2005; Takeyasu, 2012).[13] In the stimuli, nasal and fricative geminates in fact have longer V1 than stop geminates (pre-nasal V1 = 77 ms, 83 ms; pre-fricative V1 = 74 ms, 78 ms; pre-stop V1 = 57 ms, 65 ms). The phonetically longer V1 before fricative and nasal geminates should have enhanced the percept of geminates, which undermines "the longer, the better for emphasis" hypothesis. A future experiment with more controlled duration measures can address this alternative.

4.4. Inferences from lexical statistics

Another alternative explanation for the markedness hierarchy observed in the experiment is based on abstraction from existing patterns in the Japanese lexicon; that is, speakers extend some statistical patterns from the existing Japanese mimetic words and apply that statistical knowledge in the phonological judgment task. In Hamano's (1986, pp. 45–46) list of mimetic words, among those that take CVCCV-ri adverbs, in which the medial consonants are geminates, words with a [tt]-geminate are most frequent (33 forms), those with a [ss]-geminate are less frequent (13 forms), and those with an [nn]-geminates are least frequent (2 forms). Japanese speakers could have induced the preferential hierarchy stop geminates $\succ$ fricative geminates $\succ$ nasal geminates from the different frequencies of different geminates in CVCCV-ri forms (see Boersma and Hayes (2001) for a model that learns a markedness hierarchy from input frequency differences).

If this explanation were true, then the experiment shows that speakers have lexical frequency information in their lexicon, build a preferential hierarchy based on frequency information, and apply that knowledge in a wug-test (Albright and Hayes, 2003; Ernestus and Baayen, 2003; Hayes and Londe, 2006; Hayes, 2009; Zuraw, 2000, 2010, among others for similar cases in other languages).[14]

[12] Several studies have investigated the phonetic properties of geminate consonants in Japanese (Beckman, 1982; Han, 1992, 1994; Hirata and Whiton, 2005; Hirose and Ashby, 2007; Homma, 1981; Idemaru and Guion, 2008; Kawahara, 2006), but these studies did not directly compared duration ratios between stop pairs and fricative pairs.

[13] I acknowledge that there are some studies which found the opposite perceptual effect (Idemaru and Guion-Anderson, 2010; Watanabe and Hirato, 1985). See Kawahara (in press) and Takeyasu (2012) for a discussion on a potential phonological confound, however.

[14] A final possible explanation of the preferential hierarchy is semantic—Japanese mimetic ords are sound symbolic, and Hamano (1986, p. 173) notes that [t] in C2 could mean "hitting a surface" or "coming into close contact", [s] in C2 "friction" or "soft contact", and [n] in C2 "elasticity" or "weakness". One could argue, for example, that "hitting a surface" is most compatible with the emphatic meaning due to gemination, "frication" next, and "elasticity" the least. This hypothesis however needs to be implemented with a formal theory of the compatibility scale with intensification, which is beyond the scope of this paper.

4.5. Summary

The current experiment was not set out to tease apart these explanations, but the patterns revealed in this experiment are nevertheless interesting because it does show that Japanese speakers show differential preference among stop geminates, fricative geminates and nasal geminates. It is hoped that future investigations would test these possible explanations apart.

As an anonymous reviewer pointed out, what we need to tease apart the two major explanations in Sections 4.2 and 4.4 above is a language in which the frequency bias and phonological bias go the opposite way—i.e., a language in which geminate nasals are lexically the most frequent and geminate stops the least frequent. The phonetic explanation predicts that speakers of this hypothetical language would show the same preferences as Japanese speakers do. On the other hand, the lexicon-based explanation would predict that they show the opposite preferences.

5. Conclusions

Experimental investigation of the mimetic gemination preference has revealed the preferential hierarchy stop geminates ≻ fricative geminates ≻ nasal geminates in Japanese phonology. This preferential hierarchy shows that speakers can make grammatical distinctions among forms that exist in their language—a form [A] can be preferred over [B] even when both structures are attested in the language. This study thus adds a new case study to a growing body of the experimental literature showing that not all attested structures are treated alike by native speakers (Albright, 2009, 2003; Coetzee, 2008, 2009; Coleman and Pierrehumbert, 1997; Fanselow et al., 2006; Frisch et al., 2000, 2004; Hay et al., 2003; Hayes and Londe, 2006; Hayes et al., 2009; Hayes, 2009; Kawahara and Kao, 2012; Pierrehumbert, 2001; Zuraw, 2000, 2010).

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