Paradigm Uniformity Is Probabilistic: Evidence from Velar Nasalization in Japanese

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1. Introduction

This paper presents a formal analysis of recent work by Breiss et al. (2021) enriching the quantitative understanding of a well-known case of paradigm uniformity in Japanese compounds. The phenomenon in question is Voiced Velar Nasalization (VVN), a process whereby a general allophony between [g] and [ŋ] gives rise to an alternation in the initial segment of underlyingly /g/-initial second-members of compounds (N2s). This paper focuses specifically on the claim, made first by Ito & Mester (1996) and quantitatively verified by Breiss et al. (2021), that there is a link between the morphological status of the N2 (free vs. bound) and the obligatoriness of the change from free [g] to bound [ŋ] in its initial segment. Our novel contribution is a formal analysis of the frequency effect of the N2 demonstrated by Breiss et al. (2021), which we model using a Maximum Entropy (MaxEnt) grammar (Goldwater & Johnson 2003, Smolensky 1986) with scaled Output-Output Faithfulness constraints, inspired by the general approach of Coetzee & Kawahara (2013). We also provide evidence that Rendaku feeds VVN, an inter-morphemic voicing process, which gives rise to an asymmetric distribution of frequency-conditioned optionality in N2s, which we argue is due to its interaction with the broader phonotactic grammar of Japanese.

1.1. The basics of Voiced Velar Nasalization in Japanese

In the Yamanote dialect of Japanese, as well as in certain other dialect areas (Hibiya 1995, Ito & Mester 1996), [g] and [ŋ] are allophonically distributed. [g] is the default or "elsewhere" allophone, as in /gama/ → [gama] "toad", and [ŋ] occurs prosodic-word-medially as in /kagami/ → [kaŋami] "mirror". Further examples are in (1) below.

(1) a) /doku + ga/ → [doku-ŋa] ~[doku-ga] "poison moth"

b) /ga/ → [ga] "moth"

c) /doku + ga/ → [doku-ŋa], *[doku-ga] "poison fang"

d) /ga-ʒoo/→ [ga-ʒoo] "main castle" (literally "fang castle")

VVN has been discussed extensively in both pre-generative (Kindaichi 1942, Trubetskoy 1969) and generative work on Japanese phonology, but its relevance to phonological theory was first highlighted by Ito & Mester (1996, 2003b). They brought to the fore the fact that although strictly speaking the allophonic distribution of [g] and [ŋ] is a static phonotactic, it gives rise to alternations in the context of compounds. This provided them a way to study the phenomenon as a synchronic alternation, which can give insight into the way VVN is represented in the minds of speakers, a method we pursue here as well.

The data in (1) are representative of the type cited by Ito & Mester (1996, 2003b). In /doku + ga/ → [doku-ŋa] "poison fang" in (1c) the /g/-initial N2 /ga/ "fang" undergoes VVN, surfacing as [ŋa] obligatorily. Note that we can conclude that /ga/ "fang" is in fact underlyingly /g/-initial because it appears as a first-member (N1) in other compounds, such as [ga-ʒoo] "main castle" (literally "fang castle"). In /doku + ga/

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→ [doku-ŋa] "poison moth", however, the VVN is reported to be optional, with variants [doku-ga] and [doku-ŋa] both being attested and acceptable. This optionality is deemed a type of paradigm-uniformity effect (Benua 2000, Kenstowicz 2005, Steriade 2000), whereby the existence of the free /g/-initial form of the N2 /ga/ → [ga] "moth" allows for its instantiation in the compound to be optionally faithful to the surface realization of the free form. Following from this, Ito & Mester (1996, 2003b) proposed formal analyses which used Output-Output Faithfulness constraints (Benua 2000) to capture the difference in obligatoriness between VVN in compounds with bound vs. free N2s.

1.2. N2 frequency conditions VVN optionality

Breiss et al. (2021) carried out a quantitative reassessment of the claims in the literature surrounding VVN using the 2016 NHK Pronunciation and Accent Dictionary (NHK 1993), and found robust support for the optionality of VVN based on morphological boundness (see figure 1 below, which we reproduce following the methods of Breiss et al. (2021)). The figure plots on the vertical axis the number of unique compounds found in the dictionary study, divided according to whether or not their N2 exists as a free form (left, bound; right, free). Within each panel, the height of the left bar corresponds to the number of unique compounds that do not undergo VVN, and the height of the right bar corresponds to those that do. See Breiss et al. (2021) for further details. In the right facet which shows compounds with free N2, we observe substantial variability. In the left facet with bound N2, on the other hand, VVN is obligatory. This result confirms the basic findings of Ito & Mester (1996).

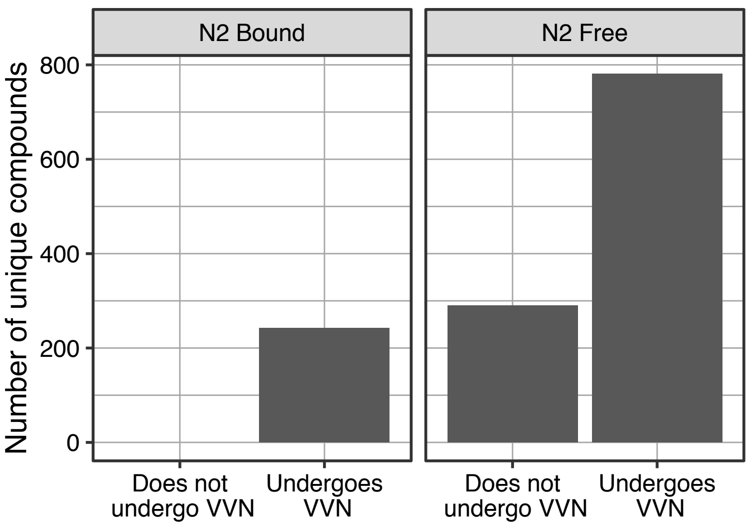

Figure 1: Number of unique compounds (vertical axis) plotted according to the morphological status of their N2 (panels) and whether or not the compound undergoes VVN (bars within each panel).

Further, Breiss et al. (2021) found that within the category of compounds with a free N2 (right facet in figure 1) a number of factors condition the optionality of VVN, including length of the compound in mora, the log-frequency of the compound as a whole, and the log-frequency of the N2 (frequency measures derived from the Balanced Corpus of Contemporary Written Japanese (Maekawa et al. 2014)). In this paper, we focus specifically on the frequency effect in N2, shown in figure 2, again reproduced following Breiss et al. (2021). This graph plots the probability of each individual compound (represented by a single dot, vertical jitter added for readability) undergoing VVN on the vertical axis, with the relative log-frequency of the compound and its N2 on the horizontal axis. Since each compound itself behaves categorically in this dataset, the sloping line plots the predicted probability of VVN across compounds. We follow Hay & Baayen (2005) in using the single measure of relative frequency of the compound and its N2, rather than the absolute frequencies of the parts; we return to this point later in the paper at section 2.5.

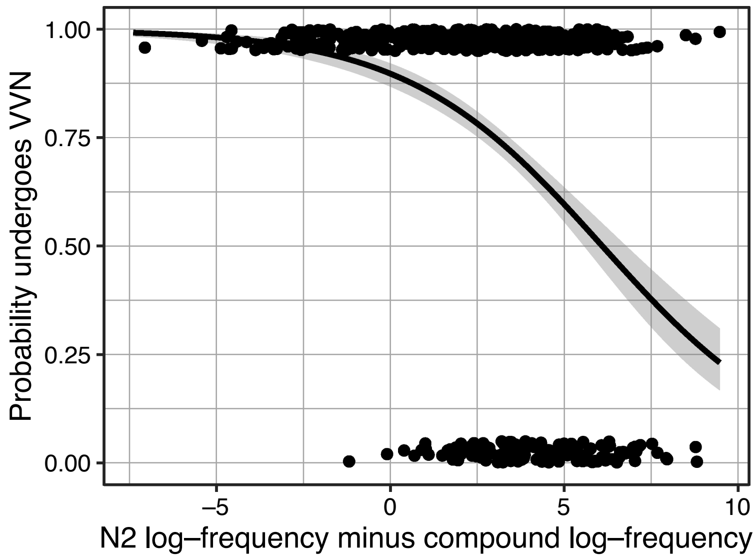

Figure 2: Probability of individual compounds (dots, vertical jitter added for readability) undergoing VVN (vertical axis) by relative log-frequency of the compound and free N2 (horizontal axis). The binomial smooth plots the predicted probability of undergoing VVN, averaged across individual compounds for a given relative log-frequency value.

The statistical robustness of the effect is confirmed using Bayesian mixed-effects logistic regression: analyzing only those compounds with free N2s (right facet in figure 1), we model the log-odds of a particular compound undergoing VVN as a function of the log-frequency of the N2 compared minus the log-frequency of the compound itself, plus a random intercept for compound identity. The model indicated that the most likely effect of increasing relative log-frequency of the N2 was a decrease in the log-odds of VVN applying in that compound ($\hat{\beta} = -13.07$, 95% CI [−31.71, −5.45).

Although this finding is compatible with the data and analysis laid out in the previous literature, there is nothing in the mechanism proposed that predicts the frequency effect we observe here. In the sections that follow, we summarize the analysis of the classical data by Ito & Mester (1996, 2003b), and then propose an extension which can capture the frequency effects observed in the data from Breiss et al. (2021).

2. Formal analysis

In building up a formal model of the N2 frequency effect, we begin by summarizing the canonical analysis of the phenomenon as put forward by Ito & Mester (2003b).

2.1. Ito & Mester (2003b)'s analysis

VVN has been the subject of two analysis by Ito & Mester, one in 1997 and one in 2003. Common to both these analyses is that they assume a treatment of the Paradigm Uniformity effect that makes reference to surface forms of morphologically-related forms (foreshadowing Benua (2000); see Ito & Mester (2003b: footnote 4) for details). They argue that in cases where VVN is obligatory, a high-ranked markedness constraint enforcing the allophony between [g] and [ŋ] forces nasalization of underlying /g/, while in cases of optional VVN, an output-oriented faithfulness constraint is freely ranked with the markedness constraint, giving rise to free variation.

We use the constraints in table 1 below to formalize this analysis, in large part adopted directly from Ito & Mester (2003b).

- ***[+son]g[+son]:** Assign one violation for a [g] between two sonorant segments in the SR.
- ***ŋ:** Assign one violation for each [ŋ] in the SR.
- **Id-io:** Assign one violation for each segment in the SR that is not identical to its corresponding segment in the UR.
- **Id-oo:** Assign one violation for each segment in the SR that is not identical to its corresponding segment in the surface base (here, the free form of the N2).

Table 1: Traditional optimality-theoretic constraints used in our analysis, adapted from Ito & Mester (2003b).

Although Ito & Mester (2003b) used a markedness constraint *VgV to enforce the allophony between [g] and [ŋ], we note that there exist cases of VVN application where the preceding segment (that is, the final segment of the first element of the compound, N1) is nasal, not a vowel. For example, the compound /nihon + go/ "Japanese (language)" is realized with VVN as [nihoŋŋo], not *[nihongo] (this particular example is also subject to an additional process of nasal place assimilation, which is orthogonal to VVN application). To account for this while preserving the insight of Ito & Mester (2003b) that [g] is more typologically natural as the default, or "elsewhere" allophone, with [ŋ] only arising prosodic-word internally, we use the constraint *[+son]g[+son] as our motivating markedness constraint.

To account for the variable nature of VVN, we also depart from prior analyses in the specific type of constraint-based grammar we use. Rather than allowing variation to arise through the free ranking of the crucial markedness and faithfulness constraints, we use a Maximum Entropy Harmonic Grammar formalism (Goldwater & Johnson 2003, Smolensky 1986). In this framework, each constraint is associated with a positive weight denoting its importance, and the grammar yields a probability distribution over candidates based on the penalties incurred by each candidate under the constraint set and weighting.

2.2. Incorporating token frequency into the model

Although the general notion of frequency at the level of types has in recent years been a crucial advancement in phonological modelling (e.g. Anttila 2002, 2006, Becker et al. 2011, Boersma & Hayes 2001, Hayes et al. 2009, Zuraw & Hayes 2017: among many others), the notion of *token* frequency specifically affecting the realization of a particular morpheme in its own right has been generally assumed to be outside the domain of generative phonological analysis. Thus, it has rarely been modeled jointly with grammatical determinants of phonological variation. Notable exceptions to this are Boersma & Hayes (2001) and Coetzee & Kawahara (2013) who still maintain an ontological distinction between grammatical and non-grammatical influences on variation, and more recent work by Zymet (2018) and Smith & Moore-Cantwell (2017) that hew less closely to the strict division between grammar-internal and extra-grammatical factors. In this paper, we follow the lead of Coetzee & Kawahara (2013) in modelling the role of token frequency with a phonological grammatical model, but argue in section 3 that certain aspects of VVN provide compelling evidence that the role of token frequency should not be considered distinct from other phonological determinants of VVN application.

Coetzee & Kawahara (2013) proposed a formal model of the role of token frequency in modulating the application of two different phonological processes: coronal stop deletion in English, and geminate devoicing in Japanese. In both these cases, higher token frequency of an individual word results in increased application of the phonological process: a word like *west* /wɛst/ is more likely to be realized without its final [t], as [wɛs], than a phonologically-similar but lower-frequency word like *jest* /dʒɛst/. Similarly in Japanese, increased word frequency results in that word being realized more often with a devoiced geminate; compare high-frequency /baggu/ → [bakku] "bag" with low-frequency /budda/ → [butta] "Buddha".

Coetzee & Kawahara (2013) used two formal devices to model these data in a constraint-based grammar. First, rather than modelling the data at the level of the individual token, they computed the average probability of undergoing the phonological process for each word, and then ranked the words by their log-frequency. They then divided these words into "bins", with each bin's overall rate of undergoing coronal stop deletion or geminate devoicing being the average of words whose individual rates of undergoing fell into the specified range. This process yielded the data that was fed to the constraint-based grammar as their object of formal analysis. Their second innovation was in indexing the bin rank to a beta distribution to enforce a linear relationship between bins, and allowing the effect of decreasing the penalty associated with violating Id-io when violated by items of higher-frequency bins to emerge. In this paper we employ the same binning method for deriving the input to our phonological model, though depart from Coetzee & Kawahara (2013) in the formal implementation of frequency in the model, as discussed at length below.

2.3. Deriving the input to the phonological grammar

Unlike the case in Coetzee & Kawahara (2013), the data underlying our model are categorical at the type level; although the Balanced Corpus of Contemporary Written Japanese provides us with the relevant token frequency information for each of the compounds and N2s, the 2016 NHK Pronouncing and Accent Dictionary lists only one preferred pronunciation for each entry. Therefore, we lack the granularity of data to make firm generalizations about token-level variation, and so treat our data as categorical within types. However, the native intuitions of the second and third authors support the possibility of token-level variation in pronunciation, and ongoing experimental work with speakers of another Japanese dialect that exhibits VVN has found that individual compounds can be realized as both undergoing and resisting VVN by the same speaker. Thus the data we model here should, as is often the case, be regarded as somewhat of an idealization of the truth.

In other aspects our approach to data preparation is similar to that of Coetzee & Kawahara (2013). First we annotated each compound for the difference in log-frequency between the compound and its N2. Then we ranked all compounds according to this difference, and divided the range into deciles, "binning" together compounds with similar log-frequency differences. Finally, to obtain the input to the phonological grammar, we took the average probability of undergoing VVN for the words in that bin. To accommodate the different bins, we also "exploded" the Id-oo constraint into ten different identical versions, and indexed each to a different frequency bin (cf. the approach taken in Moore-Cantwell & Pater 2016).

2.4. Results

These constraints in hand, we constructed a MaxEnt grammar in which each bin was an input, with two options as candidates: being faithful to the UR and retaining a [g] as the initial segment of N2 in the compound, or undergoing VVN and having the initial segment surface as [ŋ]. We also added an input corresponding to the left panel of figure 1, the case of a bound N2 which had no indexed Id-oo faithfulness constraint. which We fit the weights of the constraints using Microsoft Excel's *Solver* utility (Fylstra et al. 1998), and obtained the weights for the constraints in table 2 and figure 3 below.

- ***[+son]g[+son]:** 11.7
- ***ŋ:** 5.3
- **Id-io:** 2.8

Table 2: Weights obtained for the non-indexed constraints in our analysis.

Critically, examining the weights of the indexed Id-oo constraints, we see that their strength trends upwards with the bin number that denotes relative frequency. We can interpret this to mean that when the compound is much less frequent than the N2 (high-numbered bins), the high weight of the indexed Id-oo constraint represents the strong attractive "pull" of the surface form of the N2, making VVN relatively unlikely in these bins. However, as the compound itself rises in frequency relative to its N2, the free N2 becomes less strongly attractive relative to the strength of encoding of a high-frequency compound (represented by the strength of the general Id-io), and so the weight of the indexed Id-oo constraint is lower, allowing VVN to occur. The weights of the indexed Id-oo constraints are plotted by bin in figure 3 below.

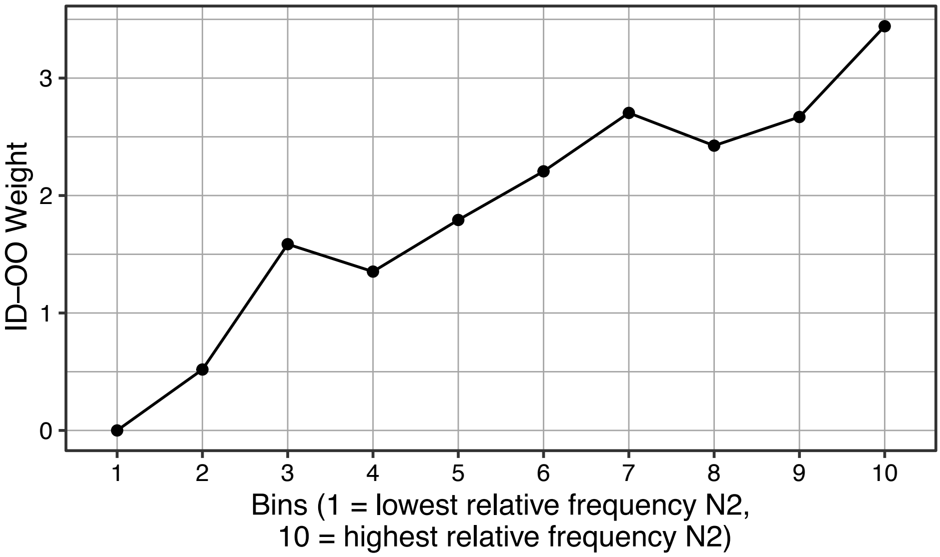

Figure 3: Weights of indexed Id-oo constraints on the vertical axis by relative frequency bin on the horizontal axis.

Qualitatively, we find that the weights of the general constraints correspond well with our intuition about the phonological phenomenon of interest – a highly-weighted contextual markedness constraint being counterbalanced by a medium-weighted general markedness constraint and a lower-weighted general faithfulness constraint, which provides a baseline rate of VVN application for compounds with bound N2s. The two lower-weighted constraints further exhibit ganging cumulativity with the indexed faithfulness constraints, which in turn reflect the frequency of the bin of N2s that they are indexed to. Quantitatively, the model fits the data very well ($R^2 \approx 0.99$).

2.5. Discussion

The analysis we have proposed incorporates token frequency into the grammar in a simple, direct way: indexing faithfulness constraints to forms of different relative frequencies. However, there are also other ways we could have implemented Coetzee & Kawahara (2013)'s core idea, which we discuss briefly here. One alternative, hinted at above, would have been to model the effect of absolute frequency of the compound and N2, rather than their relative frequencies. Hay & Baayen (2005) convincingly show that when existing lexical items compete for realization or influence on a produced form, it is the relative frequency of these elements that is crucial for the outcome, rather than their absolute frequencies. The question of how such an effect should be modeled in the phonological grammar, however, brings up a far larger question of the precise relationship between the phonological grammar, lexical retrieval, and speech production (see, among others, Zuraw 2007, Zuraw et al. 2020, Zuraw & Peperkamp 2015). The proper way to model such effects are beyond the scope of this paper, so we cleave closely to the data, and model what we feel is the most salient *characteristic* of the data in determining VVN application; however the question of whether this characteristic should be modeled in the grammar directly or arise as a side-effect of the indexation of other constraints (ex., Id-io, *[+son]g[+son], . . .) to other measures of absolute frequency remains a task for future exploration.

A second dimension along which our analysis could have varied is the way we implemented the frequency-dependence of VVN's optionality. The approach we took was maximally flexible and minimally restrictive: we simply allowed the effect of frequency on faithfulness to vary freely for each bin, without imposing any *a priori* hierarchy or ordering to the weights. We took this approach so as to impose as little theoretical assumptions on the shape of the relationship between frequency and constraint weight as possible, since we did not have any strong prior knowledge about what the shape of the function relating the two should look like. Future analyses building on our own might want to take a more restrictive position in light of an expectation of a (roughly) linear relationship between relative log-frequency and constraint weight, and thus might pursue Coetzee & Kawahara (2013)'s method of using a beta distribution to enforce a more specific relationship on the relative weighting of indexed constraint, or even follow an approach similar to linear regression, where constraints violate a single ID-OO constraint with severity according to their relative frequency.

3. Rendaku feeds VVN

Japanese exhibits a well-studied compound voicing process called Rendaku. In a simple example, the word /sora/ "sky" is realized with an initial [z] when an N2 in a compound, as in /natsu + sora/ → [natsu-zora], "summer sky". The relevance of Rendaku to VVN is that Rendaku can create the environment for VVN to apply when the second morpheme begins with /k/- and is eligible to undergo Rendaku, as noted by Ito & Mester (1999) and demonstrated in (2) below.

(2) a) /joko + kaki/ → [joko-ŋaki, *joko-gaki, *joko-kaki] "horizontal writing"
b) /kaki/ → [kaki] "writing"

This piece of evidence is interesting because unlike the case with /g/-initial N2s, there is *no* variation between [g] and [ŋ] in the realisation of /k/-initial N2s, despite the existence of a free (and potentially frequent) N2. Why should one type of N2 behave so differently from another which differs only in the voicing of one segment? We consider this question below, and propose a solution that follows from the broader word-level phonotactics of Japanese.

One possible mechanism for deriving the difference would be to assume that there is an asymmetric indexation of ID-OO constraints in CON. If /g/-initial N2s in compounds had faithfulness to their free [g]-initial forms while Rendaku-eligible /k/-initial N2s in compounds were not subject to the same faithfulness pressure, this could derive the difference we observe. However this explanation would simply pass the buck, so to speak, to CON, where we would be forced to provide an explanation about why the constraint inventory itself should be asymmetric. We do not think this explanation is viable, as we assume, in line with assumptions made in previous work on the topic by Breiss (2021), Steriade (1997), and Steriade & Stanton (2020), that the mechanisms by which surface forms influence one another in the grammar are fully general, following from the architecture of the phonological grammar and its relationship to the lexicon, rather than from the phonological substance of specific lexical items.

Instead, we propose that the asymmetry is due to the existence of [g] ~[ŋ] allophony, and the associated constraint *[+son]g[+son]. In compounds with Rendaku-eligible /k/-initial N2s, pressure to undergo Rendaku forces the repair to be in the form of [ŋ], since *[+son]g[+son] blocks the otherwise-optimal repair [g]. We find no variation between [ŋ] and [g] for these N2s since there is no [g]-initial form of the /k/-initial N2 to be faithful to; the only relevant lexically-listed forms are those with initial [k] or initial [ŋ]. There is some variation between [ŋ] and [k] in compounds with Rendaku-eligible /k/-initial N2s, but here we do not consider it part of the same phenomenon of VVN, since there is no *voiced* velar to be nasalized. Future work might fruitfully explore whether such variation in Rendaku application is also conditioned by N2 frequency (for more on the interaction of frequency and Rendaku, see Sano 2015, van de Weijer et al. 2013).

We can model this non-variation of compounds with free /k/-initial N2s alongside our primary data discussed in section 2.4 by adding an additional input with a free /k/-initial N2, and candidates outcomes in [k], [g], and [ŋ]. We also add an additional constraint RENDAKU which is violated if an N2 that is Rendaku-eligible is not realized with a voiced initial segment when it is an N2 in a compound.[1] Refitting

[1] We follow Kawahara & Tanaka (2021) in the use of a generic "cover" term for the precise definition of the Rendaku-motivating constraint, and remain agnostic as to whether an analysis in terms of obligatory realization of a compound linking morpheme whose phonological reflex is [voice] (as argued by Ito & Mester (2003a)) or whether a morphologically-specific version of a general constraint promoting intervocalic voicing (as argued by Ito & Mester (1996)) is a more appropriate treatment of Rendaku in the general case. For more on this topic, see Kawahara & Zamma (2016).

the model from section 2.4 yields a slightly different configuration of weights, but the same qualitative and quantitative results hold.

4. Conclusion

In summary, we have presented evidence that the paradigm uniformity effect previously documented and studied in Japanese is probabilistic. Further, we demonstrated based on novel corpus evidence that it is influenced largely by the frequency of the relevant N2. We noted, however, that this frequency-conditioned variation only occurs in /g/-initial N2s, not with /k/-initial ones, and argued that this asymmetry follows from the broader phonotactic context of the language. We find this a compelling reason to model the N2 frequency effect as part of, and regulated by, the phonological grammar. In this claim, we depart from previous analyses that sought simply to model the *joint* influence of grammatical and non-grammatical factors (of which frequency is one of the latter) on phonological variation. Finally, we demonstrate one approach to capturing the effect formally by scaling the weight of Id-oo constraints, following the conceptual lead of Coetzee & Kawahara (2013).

References

Anttila, Arto. 2002. Morphologically conditioned phonological alternations. *Natural Language & Linguistic Theory* 20(1). 1–42.

Anttila, Arto. 2006. Variation and opacity. *Natural Language & Linguistic Theory* 24(4). 893–944.

Becker, Michael, Nihan Ketrez & Andrew Nevins. 2011. The surfeit of the stimulus: analytic biases filter lexical statistics in Turkish laryngeal alternations. *Language*. 84–125.

Benua, Laura. 2000. *Phonological relations between words*. Psychology Press.

Boersma, Paul & Bruce Hayes. 2001. Empirical tests of the gradual learning algorithm. *Linguistic inquiry* 32(1). 45–86.

Breiss, Canaan. 2021. Base effects are probabilistic: a case study in lexical conservatism. Talk at the 95th Annual Meeting of the LSA.

Breiss, Canaan, Hironori Katsuda & Shigeto Kawahara. 2021. A quantitative study of voiced velar nasalization in Japanese. In *University of pennsylvania working papers in linguistics*, vol. 27.

Coetzee, Andries W & Shigeto Kawahara. 2013. Frequency biases in phonological variation. *Natural Language & Linguistic Theory* 31(1). 47–89.

Fylstra, Daniel, Leon Lasdon, John Watson & Allan Waren. 1998. Design and use of the microsoft excel solver. *Interfaces* 28(5). 29–55.

Goldwater, Sharon & Mark Johnson. 2003. Learning OT constraint rankings using a maximum entropy model. In *Proceedings of the stockholm workshop on variation within optimality theory*, vol. 111120.

Hay, Jennifer B & R Harald Baayen. 2005. Shifting paradigms: gradient structure in morphology. *Trends in cognitive sciences* 9(7). 342–348.

Hayes, Bruce, Péter Siptár, Kie Zuraw & Zsuzsa Londe. 2009. Natural and unnatural constraints in hungarian vowel harmony. *Language*. 822–863.

Hibiya, Junko. 1995. The velar nasal in Tokyo Japanese: A case of diffusion from above. *Language Variation and Change* 7. 139–152.

Ito, Junko & Armin Mester. 1996. Correspondence and compositionality: The ga-gyō variation in Japanese phonology. In Iggy Roca (ed.), *Derivations and constraints in phonology*. Clarendon Press Oxford.

Ito, Junko & Armin Mester. 1999. *The phonological lexicon*. na.

Ito, Junko & Armin Mester. 2003a. *Japanese morphophonemics: markedness and word structure*. Vol. 41. MIT Press.

Ito, Junko & Armin Mester. 2003b. Lexical and postlexical phonology in Optimality Theory: evidence from Japanese. In *Linguistische berichte. sonderheft 11: resolving conflicts in grammars*, vol. 11, 183–207.

Kawahara, Shigeto & Yu Tanaka. 2021. Partially activated morpheme boundaries in Japanese surnames. In *Proceedings of nels*, vol. 52.

Kawahara, Shigeto & Hideki Zamma. 2016. Generative treatments of rendaku and related issues. *Sequential voicing in Japanese compounds: Papers from the NINJAL rendaku Project*. 13–34.

Kenstowicz, Michael. 2005. *Paradigmatic uniformity and contrast*. na.

Kindaichi, Haruhiko. 1942. Ga-gyo bionron. *Onin no Kenkyû (Reprinted in Kindaichi 1967)*.

Maekawa, Kikuo et al. 2014. Balanced corpus of contemporary written Japanese. *Language resources and evaluation* 48(2). 345–371.

Moore-Cantwell, Claire & Joe Pater. 2016. Gradient exceptionality in maximum entropy grammar with lexically specific constraints. *Catalan Journal of Linguistics* 15. 0053–66.

NHK. 1993. Nhk broadcasting culture research institute.

Sano, Shin-Ichiro. 2015. The role of exemplars and lexical frequency in rendaku. *Open Linguistics* 1(1).

Smith, Brian W & Claire Moore-Cantwell. 2017. Emergent idiosyncrasy in English comparatives. In *Nels 47: proceedings of the 47th meeting of the north east linguistic society. amherst: graduate linguistic student association*.

Smolensky, Paul. 1986. *Information processing in dynamical systems: Foundations of harmony theory*. Tech. rep. Colorado Univ at Boulder Dept of Computer Science.

Steriade, Donca. 1997. Lexical conservatism. *Linguistics in the morning calm*. 157–179.

Steriade, Donca. 2000. Paradigm uniformity and the phonetics-phonology boundary. *Papers in laboratory phonology* 5. 313–334.

Steriade, Donca & Juliet Stanton. 2020. Productive pseudo-cyclicity and its significance. Talk at LabPhon 17. `https://julietstanton.github.io/files/steriade%5C_stanton%5C_labphon17.pdf`.

Trubetskoy, N. 1969. Principles of phonology [translated from the Russian by C. Baltaxe]. *Berkeley: U. of California Press*.

van de Weijer, Jeroen, Clemens Poppe & Marjoleine Sloos. 2013. Family matters: lexical aspects of Japanese rendaku. *Jeroen van de Weijer & Tetsuo Nishihara (eds.)* 129–148.

Zuraw, Kie. 2007. Frequency influences on rule application within and across words. In *Proceedings from the annual meeting of the chicago linguistic society*, vol. 43, 283–309.

Zuraw, Kie & Bruce Hayes. 2017. Intersecting constraint families: an argument for harmonic grammar. *Language* 93(3). 497–548.

Zuraw, Kie, Isabelle Lin, Meng Yang & Sharaon Pepperkamp. 2020. Competition between whole-word and decomposed representations of English prefixed words. *Morphology*.

Zuraw, Kie & Sharon Peperkamp. 2015. Aspiration and the gradient structure of English prefixed words. In *Icphs*.

Zymet, Jesse. 2018. *Lexical propensities in phonology: corpus and experimental evidence, grammar, and learning*. UCLA dissertation.

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