Token frequency in the grammar: A *wug*-test of Voiced Velar Nasalization in Japanese

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Goal setting

This talk:

- summarizes recent findings on Voiced Velar Nasalization (hence simply *nasalization*) in Japanese compounds
- focuses on the interaction of token frequency and phonological markedness in conditioning optional paradigm uniformity, blocking or allowing nasalization
- presents *wug*-test results that verify the corpus behavior of existing compounds, tests entirely novel compounds
- discusses the mechanisms in the phonological grammar needed to model these data, implications for marked phonological alternations

What is voiced velar nasalization?

In the Yamanote dialect of Japanese, [ŋ] and [g] are allophonically distributed:

- [g] occurs prosodic-word-initially, as in [gama] "toad"
- [ŋ] occurs elsewhere, as in [kaŋami] "mirror"

Extensively discussed in traditional generative and pre-generative studies of Japanese (e.g. Kindaichi, 1942; Trubetskoy, 1969; Labrune, 2012).

- Nasalization's relevance to theoretical phonology was highlighted by Ito and Mester (1996, 2003)
- Although properly a phonotactic restriction, nasalization generally discussed using data from compounds, a tradition continued here

Nasalization in compounds

Compounds provide the context for observing a synchronic alternation:

(1) a. /doku + ga/ → [doku-ŋa], *[doku-ga]
poison fang
"poison fang"

b. /ga-ʒoo/→ [ga-ʒoo]
fang castle, "main castle"

However, when N2 is also attested as a freestanding word, nasalization is reportedly optional:

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

b. /ga/ → [ga], "moth"

Corpus study by Breiss et al. (2021a)

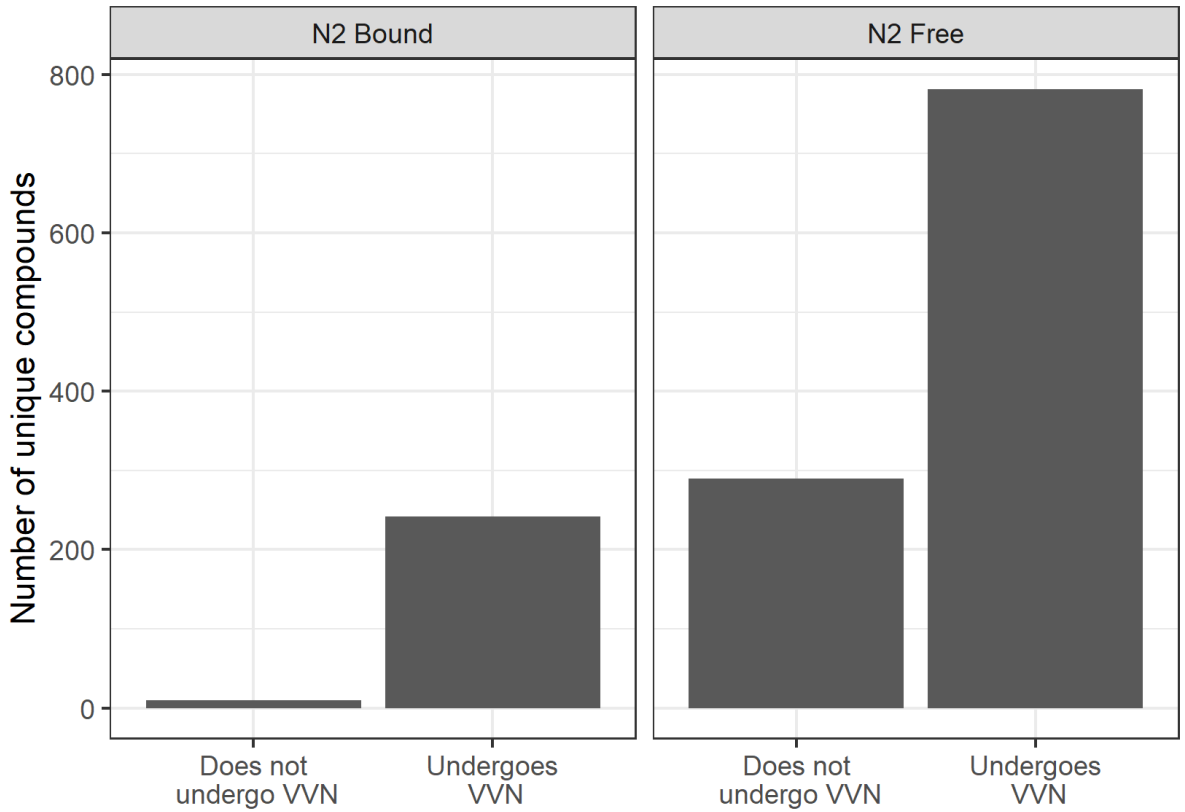
Extracted all compounds with /g/-initial N2s from the 2016 NHK Pronunciation and Accent Dictionary (Kenkyūjo, 1993).
Marked as:

- preferring/requiring nasalization, as in /hai + gan/ → [hai-ŋan] "lung cancer"
- dispreferring/resisting nasalization, as in /noo + geka/ → [noo-geka] "brain surgery".

Annotated for N2 and compound log-frequency using the Balanced Corpus of Contemporary Written Japanese (Maekawa et al., 2014)
→ left 1,323 compounds

Prosodic status of N2 matters

Ample variation in compounds with free N2s (right), near-categorical behavior in compounds with bound N2s (left).



→ What factors condition the variation observed in the right panel?

Frequency effects in phonological alternations

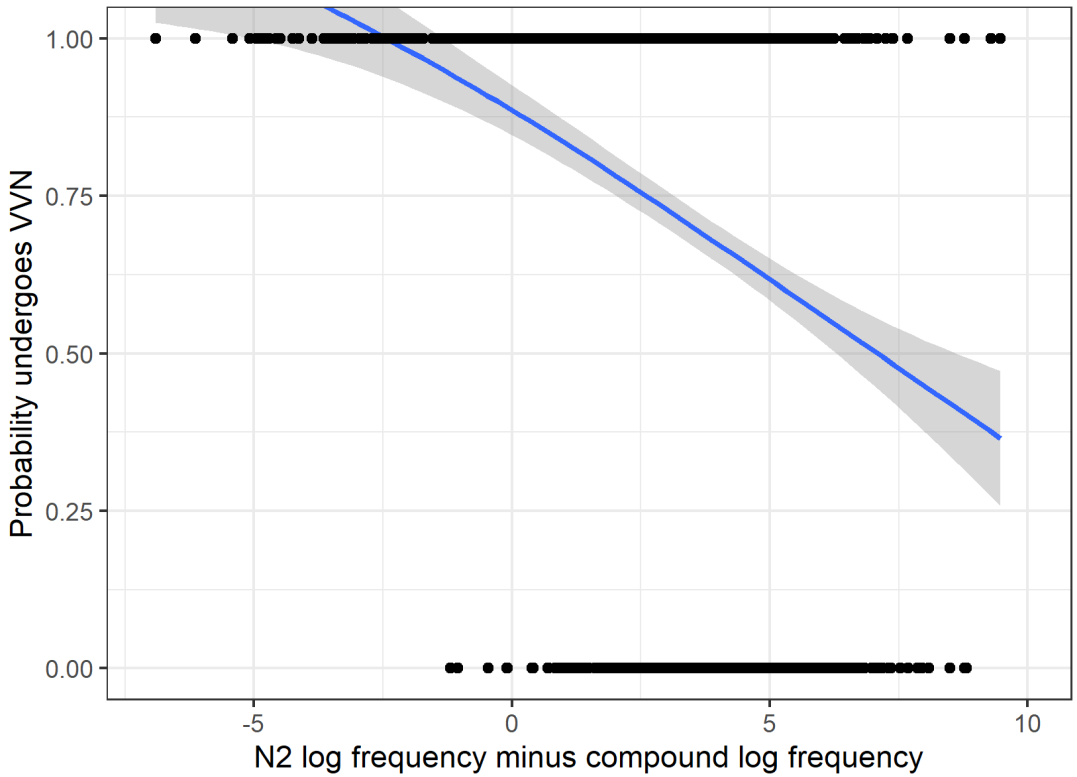
Recent work (Steriade and Stanton, 2020; Breiss, 2020, 2021) finds other phonological processes involving reference to surface forms of a paradigm are conditioned in part based on those forms' lexical characteristics like frequency and resting activation (ex., Lexical Conservatism, Steriade (1997)).

Asked the same question about nasalization, as a case of optional paradigm uniformity:

- Does relative frequency of N2 and compound influence whether nasalization applies? (cf. Hay and Baayen, 2005)

Higher N2 relative frequency decreases nasalization

The effect of relative token frequency of N2 is robust.



This finding fits with the terms of Ito and Mester (1996)'s analysis:

- Relative frequency ($\rightarrow$ increased lexical accessibility) can provide a functional basis for Output-Output faithfulness.

Rendaku feeds nasalization

Japanese exhibits a well-studied compound voicing process called Rendaku (cf. references in Kawahara, 2016):

- /naʦ͡su + sora/ → [naʦ͡su-zora] “summer sky”

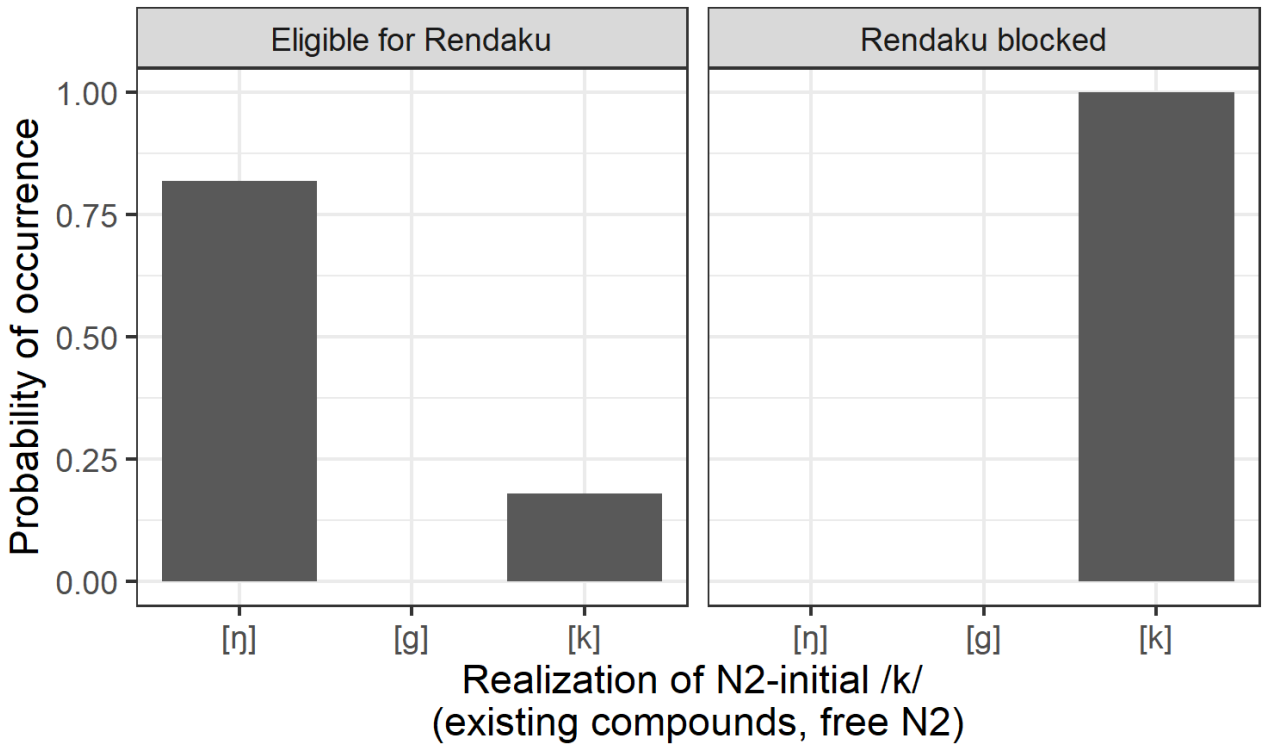
Rendaku feeds nasalization:

(3) a. /joko + kaki/ → [joko-ŋaki, *joko-gaki, *joko-kaki]
horizontal writing
“horizontal writing”

b. /kaki/ → [kaki], “writing”

No optionality in fed nasalization

In contrast to compounds with /g/-initial free N2s, there is *no* optionality or variation in nasalization for Rendaku-eligible /k/-initial N2s.



This constitutes a *saltatory alternation* (Hayes and White, 2015).

Nasalization and Rendaku create saltation

A *saltatory* phonological alternation is one where sound A is mapped to C, skipping over a faithfully-realized phonetically-intermediate B.

(4) a. /belːu **p**iʃːi/ → [belːu **β**iʃːi] "nice fish"

b. /sːu **b**inu / → [sːu **b**ĩu] "the wine"

In simpler terms: /p/ → [β], but /b/ → [b]

- data from Campidanian Sardinian (cf. Hayes and White, 2015)

Pattern is typologically rare, hard to learn, diachronically unstable (White and Sundara, 2014; White, 2014; Hayes and White, 2015; Smolek and Kapatsinski, 2018).

Nasalization and Rendaku create saltation

The interaction of nasalization and Rendaku results in saltation:

(5) a. /k/ → [ŋ] (/joko + kaki/ → [joko-ŋaki])

b. /g/ → [g] ~[ŋ], (/doku + ga/ → [doku-ga] ~[doku-ŋa])

- Rendaku-fed nasalization is categorical and non-derived /g/ only optionally nasalizes based on frequency.

Summary of corpus findings

To review, Breiss et al. (2021) found:

- Ito and Mester (1996)'s description is correct: the existence of a free N2 licenses optionality in nasalization
- Optionality is conditioned by the relative frequency of N2 and the compound as a whole
- N2 frequency effect is explainable in functional terms, and aligns with prior findings that reference to surface forms are affected by those forms' lexical characteristics
- Nasalization is fed by Rendaku; no optionality despite existence of free [k]-initial form

Why an experiment?

Corpus analysis leaves questions:

- Does frequency-conditioned variation truly exist at the token-level?
  - → in the corpus each item behaved categorically, so it is unclear whether we are observing variation across types only, or actual token-by-token variation.
  - → What about in entirely novel compounds?
- Nasalization and Rendaku yield saltation; is it productive?
  - → Typologically rare and synchronically marked type of alternation
  - → If productive, some evidence that disfavored phonological analyses may be is counterbalanced by support from lexical frequency (cf. recent work by O'Hara, 2021).

Experiment: design

Experiment structure is as follows:

1. Allophony test
2. Pre-task vocabulary test
3. Reading aloud task
4. Post-task vocabulary test
5. Demographic survey, payment

Experiment: nitty gritty

Details:

- Half of the N2s were *primed* by being asked about in the pre-task vocabulary test
- Two rounds for each participant, a few months apart, priming different N2s
- Before the second round, participants read aloud existing monomorphemes to confirm allophonic distribution of word-initial [g] and word-medial [ŋ]
- All stimuli written using Chinese characters, which do not distinguish between [g] and [ŋ]
- Conducted elicitation-and-powerpoint style by Hiro over Zoom

Experiment: participants

Recruitment via snowball sampling and word-of-mouth:

- Tested Tōhoku dialect speakers, who are also reported to have nasalization, since there remain few living native speakers of the Yamanote dialect (Hibiya, 1995).
- Participants were pre-screened to ensure allophonic distribution of [g] and [ŋ] (neutralized to [g] in most younger speakers)
- 4 participants passed screening, out of over 20 interviewed
- However, we do have $\sim$ 602 trials each!

Experiment: stimulus selection

Stimulus types:

- existing compounds with /g/-initial N2s of varying frequencies
- novel compounds with /g/-initial N2s of varying frequencies
- novel compounds with /k/-initial N2s, half Rendaku-eligible, half not
- 301 compounds in all

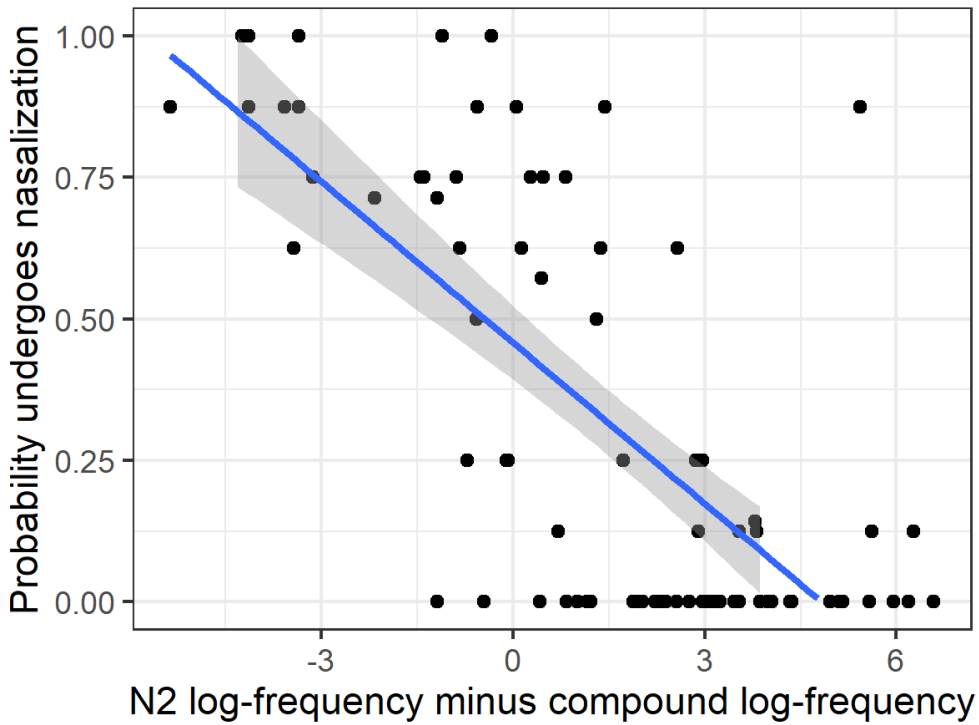
Statistical analysis

Findings reported here used:

- Bayesian mixed effects logistic regression models fit in `brms` using R (Bürkner et al., 2017) (R Core Team, 2020).
- All models had random intercepts for individual compound and subject, with random slopes of all fixed effects by subject.
- I report the median of the posterior distribution of credible values for parameters of interest, plus a 95% Credible Interval (CrI) → interpreted directly as a degree of belief about parameter estimates
- Also report probability of an effect; ranging between 0.5 and 1.

Existing compounds with /g/-initial N2s

Turning first to the N2 frequency effect in existing compounds with /g/-initial N2s, we find that it is significant and robust, as in the lexicon.



- As N2 frequency relative to compound increases, nasalization less likely, even within items (β=-0.98 CrI [-1.67, -0.12], p(β>0 = 0.98).

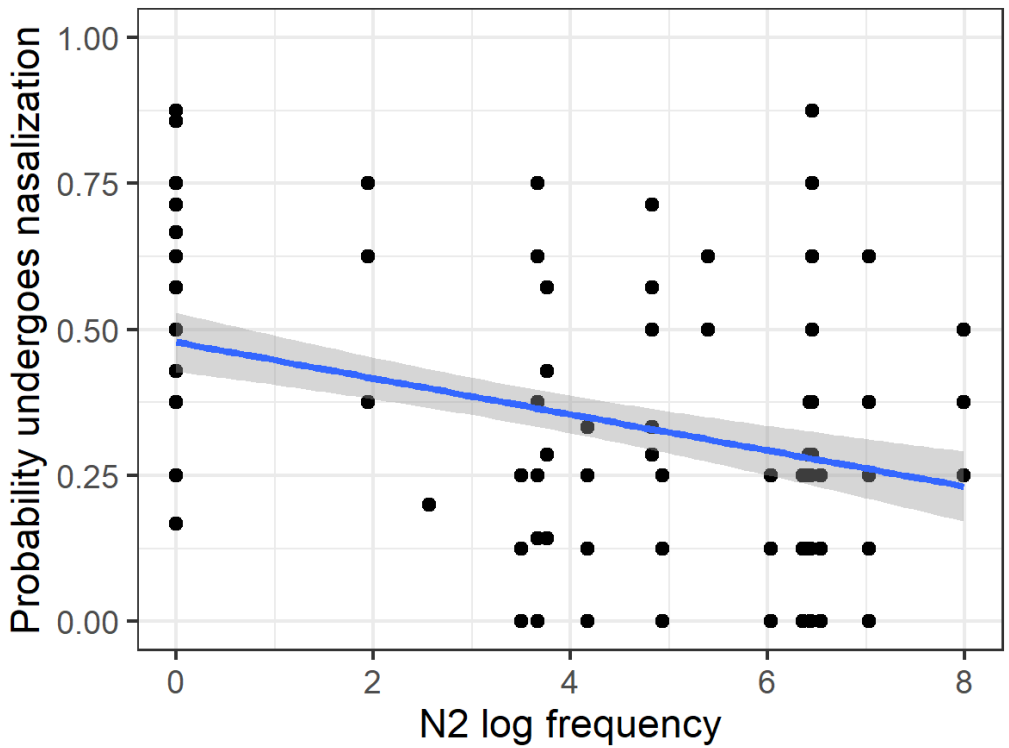
Existing compounds with /g/-initial N2s

These data can be modeled using the dual-listing approach (Zuraw, 2000; Zuraw et al., 2020; Hay, 2003; Hay and Baayen, 2005):

- The lexicon stores the compound as a whole, with nasalization applied, and also N1 and N2 separately
- In production, relative frequency of the whole vs. the parts (here, N2) conditions whether the speaker derives the form online or uses the listed form

Novel compounds with /g/-initial N2s

In novel compounds with /g/-initial N2s, with find a significant, though less pronounced, effect of N2 frequency in the same direction (β=-0.20 CrI [-0.48, 0.22], p(β>0 = 0.93)).



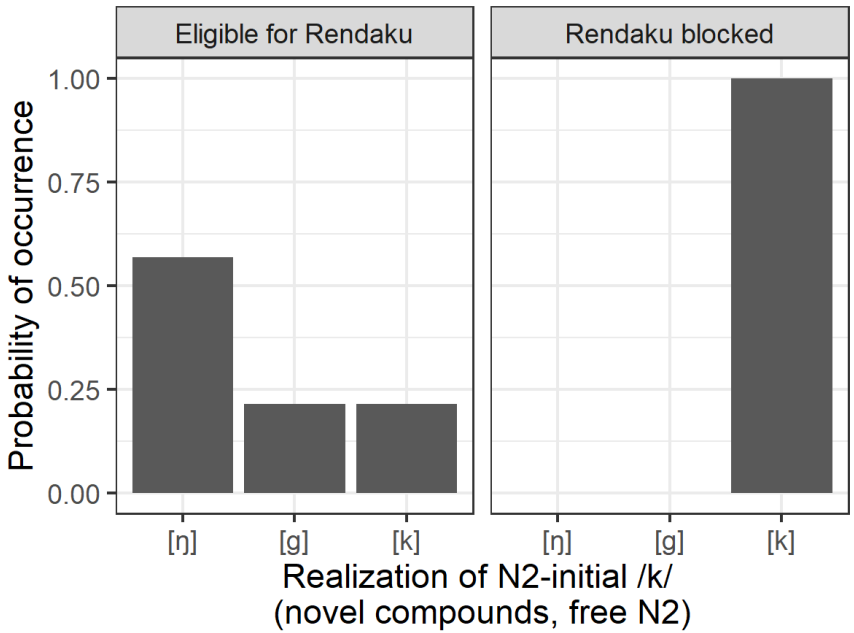
Novel compounds with /g/-initial N2s

These data are harder to model using established theories:

- Compound is entirely novel, so listing can't help us
- Suggests that the frequency of N2 itself is at play, interacting with markedness
- Possible that the frequency of individual lexical items influencing the strength of Output-Output constraints that apply to them (here the free form of N2) (Benua, 2000)

Novel compounds with /k/-initial N2s

We observe categorical blocking of nasalization when Rendaku is blocked, but variation when Rendaku is not blocked.



- Variation appears in the experiment, not the corpus
- Suggests that the saltatory pattern may be unstable

Novel compounds with /k/-initial N2s

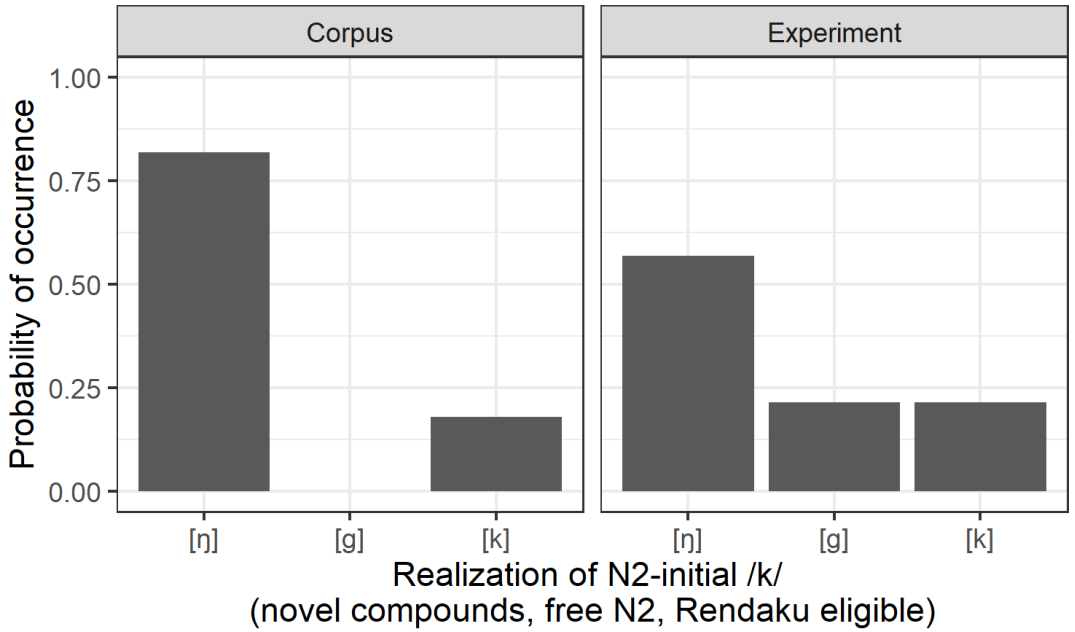
Saltation requires:

- Compounds with Rendaku-eligible /k/-initial N2s surfacing with [ŋ], as in /kita "north" + kamo "duck"/ → [kita-ŋamo]
- Compounds with high-frequency /g/-initial N2s surfacing with [g], as in /dʒuu "heavy" + gin "silver"/ → [dʒuu-gin]

Two ways for it to break down:

- Nasalization becoming obligatory (creates neutralization of /k/ and /g/ to [ŋ] intervocalically)
- Rendaku-fed nasalization gradually becoming more optional

Comparing corpus (left) and experiment (right)



- The experimental data suggest that the Rendaku-fed nasalization may be becoming more like "regular" nasalization
- This reduces (but not eliminates) the number of marked saltatory /k/→[ŋ]-but-/g/→[g] cases
- In line with predictions of Hayes and White (2015)'s model using *Map constraints from Zuraw (2013)

Summary of experimental results

Wug-test of nasalization demonstrates:

- Token-level variation is attested in existing and novel compounds with /g/-initial N2s
- This variation is conditioned by token frequency
- Suggests a role for token frequency to play both in modulating the dynamics of online vs. lexical storage and weight of OO-Faith constraints (Zuraw et al., 2020, Breiss, 2021)

What we don't yet know:

- Whether bound vs. free distinction matters *above and beyond* frequency
- Whether other factors (like prosodic length) affect novel compounds

Conclusion

The case of probabilistic paradigm uniformity in Japanese nasalization adds to the growing body of literature that implicates lexical characteristics such as frequency and resting activation in regulating probabilistic "base" effects (Zuraw, 2007; Hay, 2003; Wagner, 2012, among others)

More broadly, suggests that examining whether / how token frequency influences variable phonological phenomena can provide rich insight into both the phonological grammar, and its interaction with the broader cognitive system.

Thank you!

Thanks for your attention!

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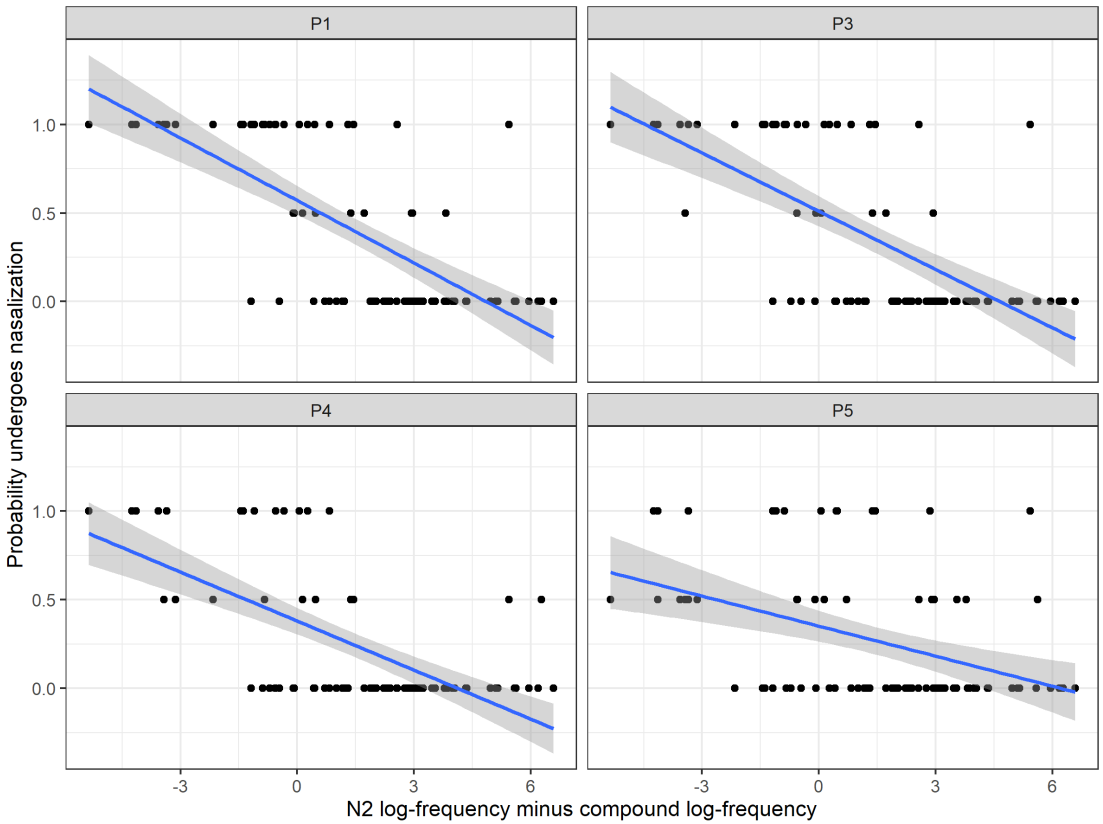
Any questions?

Existing compounds with /g/-initial N2s

Since we have lots of data for each speaker, we can observe the same effect within individuals.



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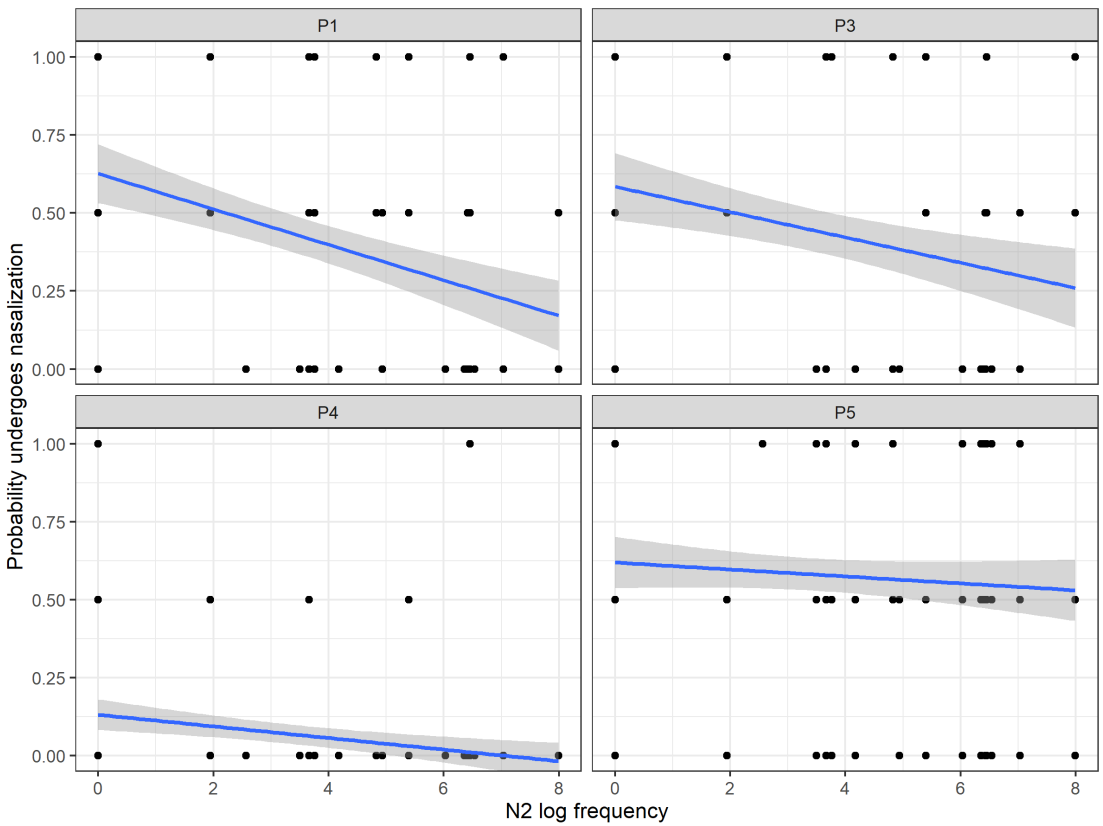
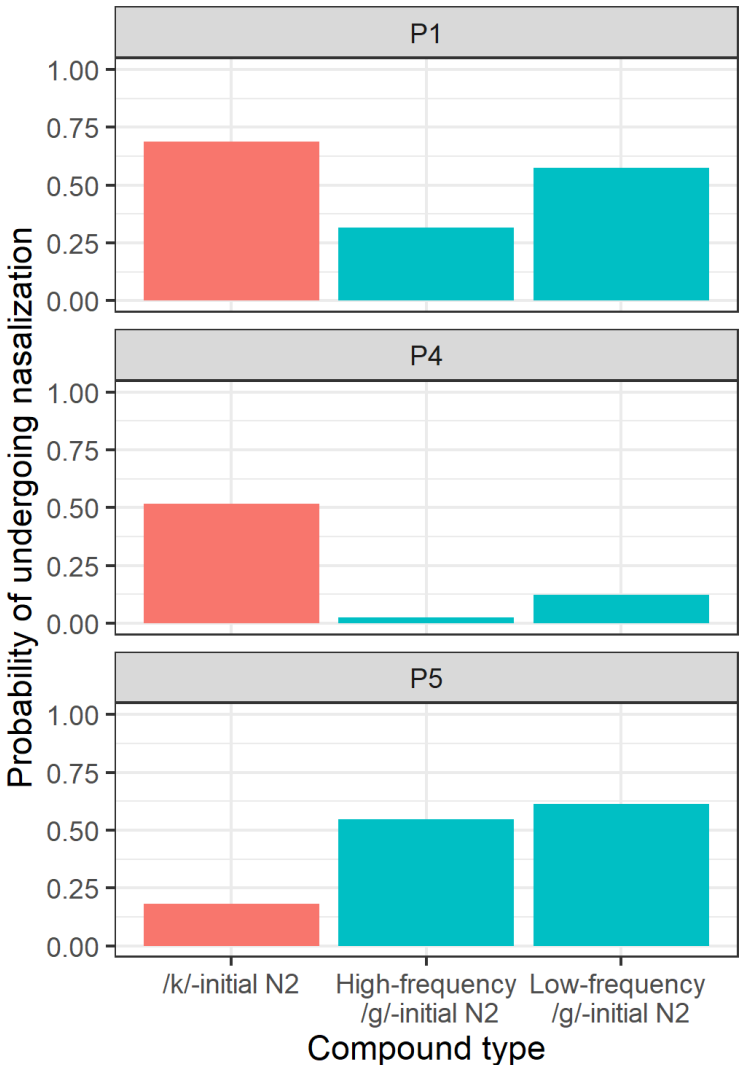
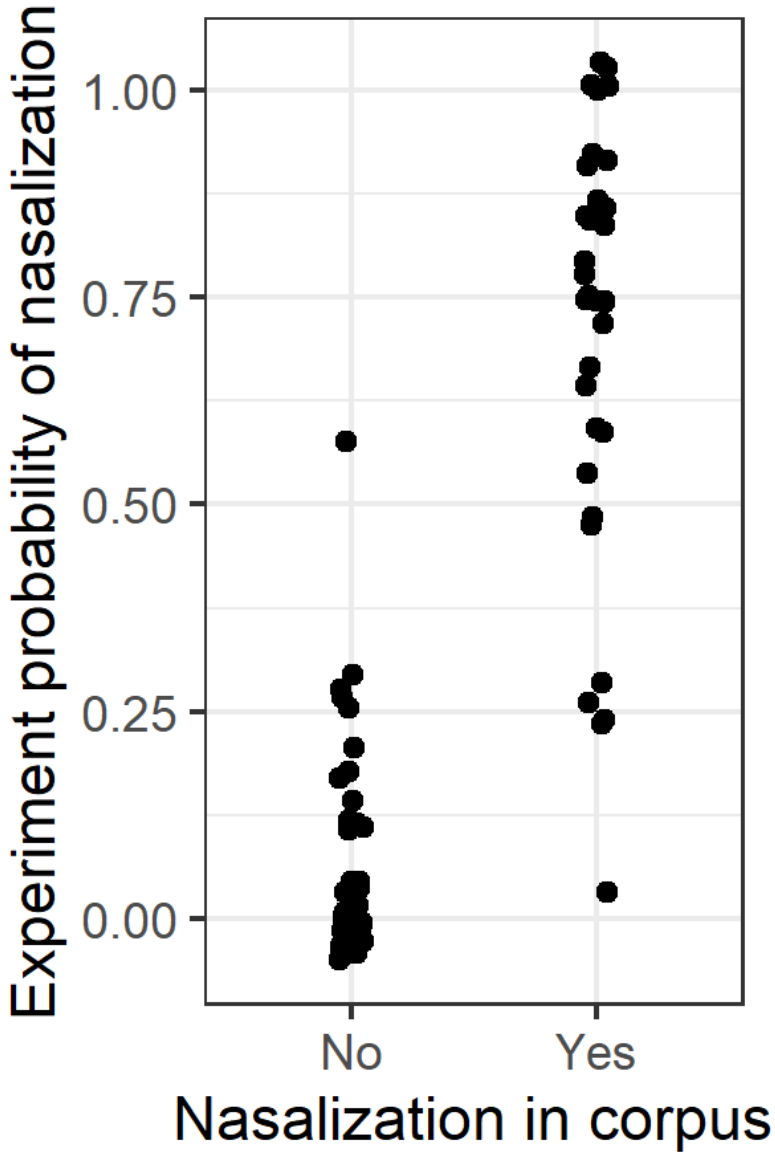


Novel compounds with /k/-initial N2s

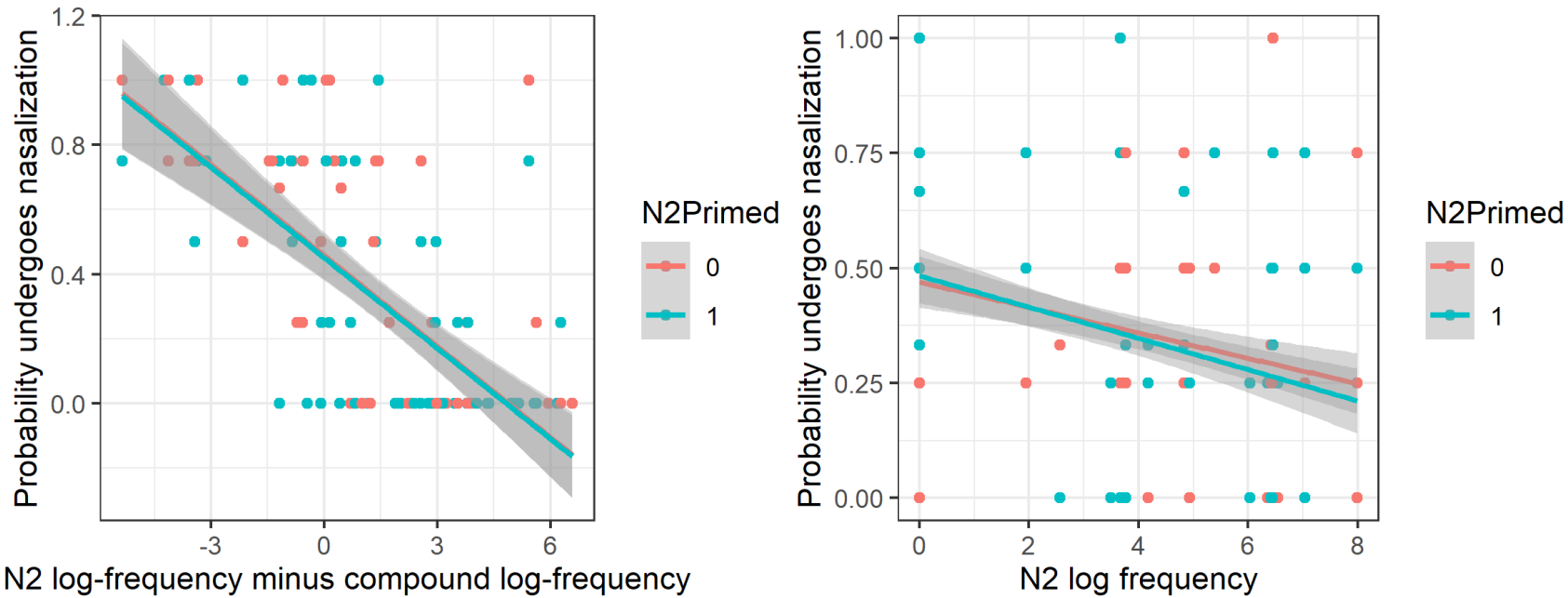
All show frequency-conditioned application of nasalization, but only 2/3 exhibit majority /k/ → [ŋ].



Corpus-experiment correlation



Priming /g/-initial N2s in existing (left) and novel (right) compounds



References I

Benua, L. (2000). *Phonological relations between words*. Psychology Press.

Breiss, C., Katsuda, H., and Kawahara, S. (2021). A quantitative study of voiced velar nasalization in japanese. Talk at the 45th Annual Penn Linguistics Conference.

Bürkner, P.-C. et al. (2017). brms: An R package for Bayesian multilevel models using Stan. *Journal of statistical software*, 80(1):1–28.

Hay, J. (2003). *Causes and consequences of word structure*. Psychology Press.

Hay, J. B. and Baayen, R. H. (2005). Shifting paradigms: Gradient structure in morphology. *Trends in cognitive sciences*, 9(7):342–348.

Hayes, B. and White, J. (2015). Saltation and the p-map. *Phonology*, pages 267–302.

References II

Hibiya, J. (1995). The velar nasal in tokyo japanese: A case of diffusion from above. *Language Variation and Change*, 7:139–152.

Ito, J. and Mester, A. (1996). Correspondence and compositionality: The ga-gyō variation in japanese phonology.

Ito, J. and Mester, A. (2003). *Japanese morphophonemics: Markedness and word structure*, volume 41. MIT Press.

Kawahara, S. (2016). Psycholinguistic studies of rendaku. *Perspectives on rendaku: Sequential voicing in Japanese compounds. Berlin: Mouton.*

Kenkyūjo, N. H. B. (1993). Nhk broadcasting culture research institute.

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

References III

Labrune, L. (2012). *The phonology of Japanese*. Oxford University Press.

Maekawa, K., Yamazaki, M., Ogiso, T., Maruyama, T., Ogura, H., Kashino, W., Koiso, H., Yamaguchi, M., Tanaka, M., and Den, Y. (2014). Balanced corpus of contemporary written japanese. *Language resources and evaluation*, 48(2):345–371.

O'Hara, C. P. (2021). *Soft Biases in Phonology: Learnability meets grammar*. PhD thesis, University of Southern California.

R Core Team (2020). *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria.

References IV

Smolek, A. and Kapatsinski, V. (2018). What happens to large changes? saltation produces well-liked outputs that are hard to generate. *Laboratory Phonology: Journal of the Association for Laboratory Phonology*, 9(1).

Steriade, D. (1997). Lexical conservatism. *Linguistics in the morning calm*, pages 157–179.

Trubetskoy, N. (1969). Principles of phonology [translated from the russian by c. baltaxe]. *Berkeley: U. of California P.*

Wagner, M. (2012). Locality in phonology and production planning. *McGill working papers in linguistics*, 22(1):1–18.

White, J. (2014). Evidence for a learning bias against saltatory phonological alternations. *Cognition*, 130(1):96–115.

References V

White, J. and Sundara, M. (2014). Biased generalization of newly learned phonological alternations by 12-month-old infants. *Cognition*, 133(1):85–90.

Zuraw, K. (2007). Frequency influences on rule application within and across words. In *Proceedings from the Annual Meeting of the Chicago Linguistic Society*, volume 43, pages 283–309. Chicago Linguistic Society.

Zuraw, K. (2013). *MAP constraints.

Zuraw, K., Lin, I., Yang, M., and Pepperkamp, S. (2020). Competition between whole-word and decomposed representations of english prefixed words. *Morphology*.

Zuraw, K. R. (2000). *Patterned exceptions in phonology*. PhD thesis.