Phonological Externalization volume 5 (2020), 13-24.
Hisao Tokizaki (ed.), Sapporo University.

Representing Tones in Precedence-free Phonology

Kuniya Nasukawa

Tohoku Gakuin University

ABSTRACT. Precedence-free Phonology (PfP) limits representational redundancy and enhances theoretical restrictiveness. This paper argues that tone should, like other aspects of melodic representation in PfP, be represented by hierarchical structure consisting only of head-dependency relations between tonal units, rather than by autosegmental tonal tiers that encode precedence relations between tonal units.*

Keywords: Precedence-free Phonology, tones, laryngeal elements, head-dependency, externalisation

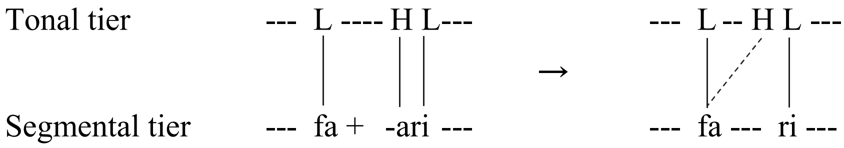
1. The representation of tones: autosegmental tiers and precedence

Phonological analysis has revealed that tonal patterns are typically stable, i.e. unaffected by segmental properties (Goldsmith 1976, et passim). This has led phonologists to conclude that tonal units are autosegments which are arranged on separate levels or tiers. An example from Margi (a Chadic language: Hoffman 1963, Katamba 1989) is given in (1). When the definite suffix *-ari*, with its HL tones (a sequence of high and low tones), is added to the definite form *fà*, the suffix-initial vowel is deleted to produce the form *fǎrì* (rather than *fàárì*). What is important here is that the underlying LHL tone pattern is preserved, even though the H which was originally associated with the suffix-initial vowel loses its docking site and then links to the preceding stem-final vowel instead.

* Part of an earlier version of this paper was presented at the workshop on nasality and laryngeal representations in phonology held at the University of Essex, Colchester, U.K. on 8 January 2020 and at the 10th workshop on the phonological externalization of morphosyntactic structure held at Tokyo University on 15 February 2020. My thanks go to the participants of the workshops for their constructive comments, and to Phillip Backley for discussion and corrections of an earlier draft. This work was supported by the following MEXT/JSPS KAKENHI grants: Grant-in-Aid for Scientific Research on Innovative Areas #4903 (Evolinguistics) Grant Number JP20H05007, Grant-in-Aid for Scientific Research (S) Grant Number JP19H05589, Grant-in-Aid for Scientific Research (A) Grant Number JP19H00532 and Grant-in-Aid for Scientific Research (B) Grant Number JP15H03213.

(1) Margi (Katamba 1989: 198; data from Hoffman 1963)

fà (INDEFINITE 'farm') + *-ari* (DEFINITE SUFFIX) > *fărì* (DEFINITE 'farm')



This illustrates the autosegmental nature of tones, and supports the shift away from classical SPE-type phonological representations (Chomsky and Halle 1968) in which an utterance is regarded as a set of linearly ordered segments consisting of unordered bundles of primes. Autosegmental tiers ensure that some phonological properties are treated as belonging to prosody rather than to melody (segments). Note that tonal tiers such those in (1) incorporate precedence relations between tonal units, just like segmental tiers do, although tonal tiers are independent of segmental tiers (or in some theories, skeletal tiers). This kind of precedence-based structure is a well-established way of representing tones. However, it is not consistent with the Precedence-free Phonology (PfP) model of phonological representation, where precedence relations are completely absent at all levels of phonological structure in order to eliminate representational redundancy and strengthen theoretical restrictiveness (Nasukawa 2014, 2016, 2017ab; Nasukawa and Backley 2017, 2018; Backley and Nasukawa 2020; Lin 2020; Onuma and Nasukawa 2020). This paper considers how PfP can represent tones—which in standard approaches are assumed to be linearly ordered on tonal tiers.

The paper is structured as follows. First, in section 2 I briefly review how phonological entities (other than tones) which are smaller than a syllable are represented in PfP. Then in section 3 I argue how tonal patterns are formally represented without referring to precedence. I also discuss the question of where to locate tonal properties within the hierarchical phonological structure. Section 4 concludes the discussion.

2. Melodic representations in Precedence-free Phonology

2.1 Representing vowels

Precedence-free Phonology aims to limit representational redundancy and enhance theoretical restrictiveness. To facilitate this, the only formal structural units it permits are melodic primes called 'elements', which have a dual function: they represent melodic properties and they also project onto higher levels as organizing units.

In PfP, a 'nucleus' is represented by a single element chosen from the set of three resonance elements |A|, |I| or |U|; the choice of element is parametric, based on the phonetic quality of a language's baseline resonance, e.g. English selects |A| (realised as [ə] in its acoustically weak form), Fijian selects |I| (giving [ɨ]) and Japanese selects |U| (giving [ɯ]) (Nasukawa 2014). By contrast, full vowels have complex structures in which the baseline element takes one or more dependent elements, as given in (2). These examples show vowels which take |A| as their baseline resonance, as found in languages such as English and German.

(2) Vowel representations

a. [ə]

|A|

b. [i]

    |A|
|A| |I|

c. [u]

    |A|
|A| |U|

d. [a]

    |A|
|A| |A|

The structure in (2a) has a baseline element without any dependent elements, so it is phonetically realized as the unrounded central vowel [ə]. On the other hand, when the baseline takes |I|, |U| or |A| as a dependent, the acoustic pattern of this dependent element overrides that of the baseline. As a result, the structures are phonetically realized as [i], [u] and [a] respectively, as illustrated in (2b), (2c) and (2d). What these figures show us is that when head-dependent structure is pronounced, the relative prominence of dependents is reflected directly in the overall phonetic outcome. This is defined by the following principle of phonetic realisation.

(3) The principle of phonetic realization of head-dependency structure (Nasukawa 2014, 2015, 2016, 2017ab; Nasukawa and Backley 2015, 2017; Backley and Nasukawa 2018) Dependents, which are not necessary for structural well-formedness, are phonetically more salient in terms of their modulated carrier signal than heads, which are important for building structure.

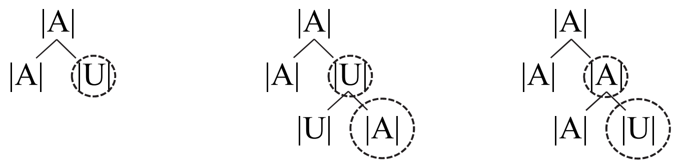
In the phonology-phonetics mapping process, the relative salience of (dependent) elements corresponds to the relatively large modulations of the carrier signal with which salient elements are phonetically realised.[1] This is found not only in structures which consist of two

[1] Harris (2009) claims that the carrier signal makes it possible for linguistic messages to be heard while the energy associated with a modulated carrier signal contains linguistically contrastive properties that allow a listener to recognise morphemes/words. As discussed in Ohala (1992), Ohala and Kawasaki-Fukumori (1997), Traunmüller (1994, 2005) and Harris (2006, 2009), the carrier signal in speech manifests itself as a schwa-like quality (which is characterized by an absence of converging formants in its periodic signature). The size of the modulations of this carrier signal are then defined in terms of acoustic attributes such as periodicity, amplitude, spectral shape, fundamental frequency and duration/timing.

elements, but also in more complex structures involving further levels of embedding, as illustrated in (4b) and (4c).

(4) Varying sizes of carrier signal modulation in complex vowel structures

a. [u] b. [ɒ] c. [o]



For example, the mid vowels [ɒ] and [o] have complex structures in which their constituent elements |A| and |U| form asymmetric relations. In this model, unlike in standard Government Phonology, Element Theory and Dependency Phonology, the |A|-headed set of |A|+|U| is realized as [ɒ] when |A| is a dependent and as a less open [o] when |U| is a dependent, as shown in (4b) and (4c) respectively (where larger circles denote a bigger contribution in terms of salience by the relevant element).

2.2 Representing consonants: laryngeal contrasts

In PfP, the 'consonant' portion of a representation has structures similar to that employed for 'vowels', adhering to the same principle of phonetic realization described in (3): i.e., dependents are phonetically more salient than heads in terms of carrier signal modulations.

As in vowel structures, there is a parametric choice of baseline element in a 'consonantal' domain: either |H| (or 'noise', its acoustic pattern containing high-frequency aperiodic energy) or |ʔ| (or 'edge', its acoustic pattern involving an abrupt and sustained drop in overall amplitude), but significantly, not |L| (or 'murmur', its acoustic pattern being characterized by a broad resonance peak at the lower end of the frequency range) (Nasukawa and Backley 2018).

(5) Laryngeal contrasts in a 'consonantal' domain

a. [h] b. aspiration c. true voicing d. nasality

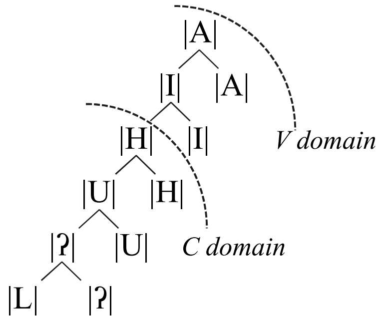
The bare baseline |H| in (5a) is realized as [h], which marks the pre-deletion stage on the lenition trajectory (Harris 1994: 119–124). But when baseline |H| takes a second |H| as a dependent, the resulting structural set is realized as aspiration, as shown in (5b); this represents positive VOT, which is an exaggerated form of baseline [h]. When the dependent is |L|, on the other hand, the complex structure is phonetically realized as obstruent voicing, as shown in (5c); this corresponds to negative VOT, which is a more salient form of |L| (Nasukawa 2017).

Note that the edge element |ʔ| can also serve as the baseline in ‘consonantal’ expressions because like |H|, but unlike |L|, |ʔ| is inherently voiceless (Backley and Nasukawa 2009, 2018; Backley 2011) and therefore produces a significant modulation of the carrier signal (which is inherently voiced). When |L| is not a dependent of |H|, then the whole expression of the domain is phonetically realized as a nasal consonant, as in (5d). On the other hand, obstruent voicing comes from |L| as a dependent of baseline |H| (Nasukawa 2005: 74–89).[2]

2.3 Representing syllable-sized structure

With respect to the hierarchical structure which forms a C-domain, it is typically headed by either |H| or |ʔ|, as described above. Now let us turn to the relation between the C- and V-domains. In PfP, the C-domain (which causes a significant modulation of the carrier signal, which is inherently voiced) is dominated by a V-domain comprising vowel elements. This conforms to the principle of phonetic realization of head-dependency structure in (3), which prescribes that dependents are phonetically more salient than heads in terms of carrier signal modulations.

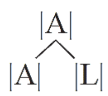
(6) The structure of [gi] in voicing languages (Nasukawa et al. 2019 and references therein)



C domain > V domain in terms of the degree of carrier signal modulations

[2] In addition, it should be noted that |L| manifests itself as nasality even when |ʔ| is absent, as illustrated in (a). Without |ʔ| and |H|, the phonetic outcome of |L| contributes to the V-domain: i.e., it represents the nasal resonance in a nasal(ised) vowel, as in (b).

a. [˜] b. nasal vowel [ã]



3. Tonal representations in Precedence-free Phonology

3.1 Representing tones

Following arguments in Halle and Stevens (1971) and Halle (1997), PfP follows standard Element Theory (Harris 1994, Backley 2011, Kula 2012) in exploiting |L| and |H| not only as units for expressing phonation contrasts (7a) but also as tonal units (7b), since phonation contrasts and tone are both associated with laryngeal-source activities.

(7) |L| and |H| and their phonetic correlates (Harris 1994, Backley 2011; cf. Halle and Stevens 1971, Nasukawa and Backley 2018)

	a. *Consonants*		b. *Vowels*	
	realization	*articulatory execution*	*realisation*	*articulatory execution*
|L|	(truly) voiced	slack vocal cords	low tone (pitch)	slack vocal cords
|H|	voiceless	stiff vocal cords	high tone (pitch)	stiff vocal cords

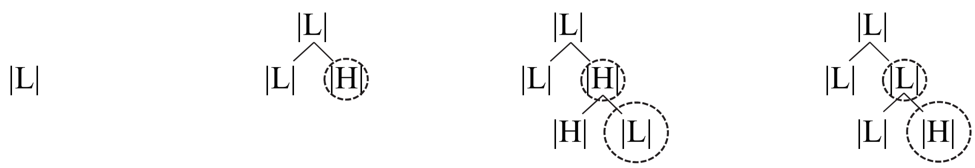
As (7) shows, the difference between phonation and tonal contrasts comes down to whether |L|/|H| is associated with a consonant expression or a vowel expression. The strong correlations between voicing and low tone and between voicelessness and high tone are confirmed by analyses of tonogenesis (Yip 1980, Bao 1990 and others).

Models which use the elements |L| and |H| follow other approaches to tonal representation in that they assume |L| and |H| must be linearly organized in order to account for phenomena including tone sandhi, even though they are thought to reside on their own autosegmental tier(s) (Goldsmith 1990, Hyman 1993 and others). However, PfP formally excludes all reference to precedence relations, which raises the question of how the theory handles tonal representations. The answer developed here is that, like the melodic representations discussed in section 2, the tonal categories |L| and |H| also enter into asymmetric relations and form hierarchical structure.

Unlike the C-domain discussed in section 2.2, |L| is assumed to be the baseline of a tonal expression; this stems from the observation that |L| is more basic than |H| in terms of phonological markedness (although this does not exclude the opposite case). On this basis (8a) shows a bare |L| as the tonal baseline.

(8) Tonal contrasts in PfP

a. low tone b. high tone c. rising tone (LH) d. falling tone (HL)



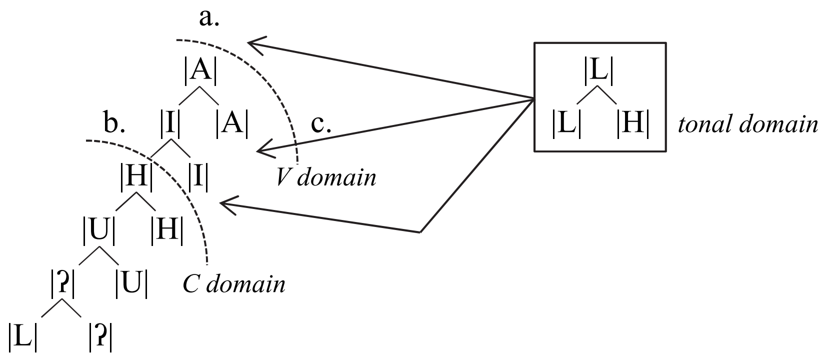
On the other hand, when baseline |L| takes |H| as a dependent, the resulting complex structure is phonetically realized as high tone, as in (8b), where the acoustic signature of head |L| is overridden by that of |H| since the dependent |H| is more salient than its head |L| in terms of the degree of carrier signal modulation. It is also possible for a structure with the baseline |L| to take a second |L|. The resulting expression may then be realized as low tone, which is lower than the phonetic manifestation of the sole |L| in (8a). It is assumed that this low tone with a dependent |L| is employed in languages with level tones.

Regarding tonal contours, I assume that rising LH is the phonetic manifestation of the |H|-headed [HL] set which is a dependent of the baseline |L|, as shown in (8c). Here the most deeply embedded dependent |L| is phonetically realized before its head |H| (cf. Nasukawa 2016, Nasukawa et al. 2019). By contrast, falling HL is the phonetic manifestation of the |L|-headed [LH] set which is a dependent of the baseline |L|, as in (8d). Note that in both cases, the most deeply embedded element is phonetically the most salient. Given this, other tonal types may be represented by extending the structure-building patterns in (8). In the next section, the discussion moves on to consider where the tonal domain is located within PfP's hierarchical structure.

3.2 Locating the tonal domain in hierarchical structure

Tones display a strong correlation with vowels because they are phonetically realized on vowels. There are therefore three candidates for the location of the tonal domain: either (9a) the position which dominates the V-domain, or (9b) the position which is dominated by the V-domain and dominates the C-domain, or (9c) the position which is directly dominated by the head of the V-domain (|A|) but has no dependent domain.

(9) Two candidates for the location of the tonal domain



First consider (9b) and (9c), which are both dominated by the V-domain. If the existence of vowel structure is a prerequisite for the existence of phonological tone, then both (9b) and (9c) may be suitable candidate locations since they are both structurally dominated by the V-domain. The only difference between (9b) and (9c) is whether they have dependent(s) or not: (9b) typically has an associated C-domain while (9c) has no dependent domain. However, (9b) does not seem an appropriate location for the tonal domain because the domain which intervenes between the C- and V-domains must be structurally transparent in order to facilitate a range of common assimilatory processes such as palatalization and velarisation between the C-domain ('onset') and the V-domain ('nucleus'). Positioning the tonal domain in the (9b) location could hinder the application of processes such as assimilation between C and V. By contrast, no such problem arises with the location in (9c).

Next consider (9a), which is the position dominating the V-domain. In contrast to the above, if the grammatical properties of tones control the behaviour and quality of vowels, then (9a) would be an appropriate location for the tonal domain since the V-domain is dominated by the tonal domain. Furthermore, this structure does not prevent assimilation processes from taking place between the C- and V-domains.

At this stage in the study of tonal representation in PfP, we may provisionally regard (9a) and (9c) as both being potential locations for the tonal domain. We may assume that (9a) is appropriate for register tones, which are typically found in Bantu languages, because register tones typically display complex tonal interactions independently of segmental structure but are triggered by grammatical (marking) requirements. On the other hand, (9c) may be suitable for the contour tones that are typically observed in languages like modern Chinese dialects, because they are lexical properties which express semantic contrasts. A similar argument is found in the literature (Huang 1980, Clements 1983, Hyman 1986, Manfredi 1993, Snider and van der Hulst 1993) in the context of autosegmental phonology. In order to validate this suggestion, further investigation is required.

4. Summary

This paper has explored the formal representation of tonal expressions in Precedence-free Phonology. This approach employs the privative laryngeal elements |L| and |H| as tonal units (Harris 1994, Backley 2011), but rather than making use of autosegmental tiers, it assumes that |L| and |H| enter into asymmetric (head-dependency) relations and form hierarchical structure. In a tonal expression, |L| is regarded as the structural baseline, with a sole |L| being phonetically realized as low tone. Then, when the baseline |L| takes |H| as a dependent, the resulting complex structure is phonetically realized as high tone (since the acoustic signature of the head |L| is masked by that of the dependent |H|, which is acoustically more prominent in terms of the degree of its carrier signal modulations). With respect to tonal contours, for example, rising LH is the phonetic outcome of the |H|-headed [HL] set, where the most deeply embedded dependent |L| is phonetically interpreted before its head |H|. On the other hand, falling HL is the phonetic outcome of the |L|-headed [LH] set, where the most deeply embedded dependent |H| is realized before its head |L|. Other types of tonal expression are hierarchically represented by extending this line of argument.

Regarding the location of the tonal domain within PfP's hierarchical structure, there are two possibilities: (i) the position dominating a V-domain and (ii) the dependent position of the head of a V-domain. It is assumed that (i) is for register tones typically found in Bantu languages, while (ii) is for contour tones typically observed in languages like modern Chinese dialects.

This paper is merely a first attempt to represent tones in PfP. To determine whether the proposed structure for tonal patterns is psychologically real or not, further investigation is needed in conjunction with cross-linguistic research not only on tone languages but also on other language types which employ tone, such as pitch-accent languages.

References

Backley, Phillip. 2011. *An introduction to Element Theory*. Edinburgh: Edinburgh University Press.

Backley, Phillip and Kuniya Nasukawa. 2009b. Representing labials and velars: a single 'dark' element. *Phonological Studies* 12, 3–10.

Backley, Phillip and Kuniya Nasukawa. 2020. Recursion in melodic-prosodic structure. *Morpheme-internal recursion in phonology*, ed. by Kuniya Nasukawa, 11–35. Boston and Berlin: Mouton de Gruyter.

Bao, Zhi Ming. 1990. *On the status of tone*. Ph.D. dissertation, Massachusetts Institute of Technology.

Chomsky, Norm and Morris Halle. 1968. *The sound pattern of English*. New York: Harper and Row.

Clements, George N. 1983. Tone and syntax in Ewe. *Elements of tone, stress and intonation*, ed. by Donna Jo Napoli, 21–99. Washington, D.C.: Georgetown University Press.

Goldsmith, John. 1976. *Autosegmental phonology*. Ph.D. dissertation, MIT.

Goldsmith, John. 1990. *Autosegmental and metrical phonology*. Oxford: Blackwell.

Halle, Morris. 1997. Some consequences of the representation of words in memory. *Lingua* 100, 91–100.

Halle, Morris and Kenneth Stevens. 1997. A note on laryngeal features. *Quarterly Progress Report* 101, 198–212. Cambridge, MA: Research Laboratory of Electronics, MIT.

Harris, John. 1994. *English sound structure*. Oxford: Blackwell.

Harris, John. 2006. The phonology of being understood: Further arguments against sonority. *Lingua* 116 (10), 1483–1494.

Harris, John. 2009. Why final devoicing is weakening. *Strength relations in phonology*, ed. by Kuniya Nasukawa and Phillip Backley, 9–46. Berlin and New York: Mouton de Gruyter.

Hoffman, Carl. 1963. *A grammar of the Margi language*. Oxford: Oxford University Press.

Huang, Cheng-The James. 1980. The metrical structure of terraced-level tones. *Cahiers Linguistiques d'Ottawa*, *Proceedings of the 10th conference of the North Eastern Linguistic Society*, ed. John T. Jensen, 257–270.

Hyman, Larry M. 1986. The representation of multiple tone heights. *The phonological representation of suprasegmentals*, ed. by Koen Bogers, Harry van der Hulst and Maarten Mous, 109–152. Dordrecht: Foris.

Hyman, Larry M. 1993. Register tones and tonal geometry. *The Phonology of tone: The representation of tonal register*, ed. by Harry van der Hulst and Keith Snider, 75–108. Berlin and New York: Mouton de Gruyter.

Katamba, Francis. 1989. *An introduction to phonology*. London and New York: Longman.

Kula, Nancy C. 2012. On the representation of tone in Element Theory. *Sound structure and sense: Studies in memory of Edmund Gusssmann*, ed. by Eugeniusz Cyran, Henryk Kardela and Bogdan Szymanek, 353–370. Lublin: Wydawnictwo KUL.

Lin, Chihkai. 2020. Decomposition and recursive structure: Glide formation and vowel lowering in East Asian languages. *Morpheme-internal recursion in phonology*, ed. by Kuniya Nasukawa, 117–142. Boston and Berlin: Mouton de Gruyter.

Manfredi, Victor. 1993. Spreading and downstep: Prosodic government in tone languages. *The Phonology of tone: The representation of tonal register*, ed. by Harry van der Hulst and Keith Snider, 132–184. Berlin and New York: Mouton de Gruyter.

Nasukawa, Kuniya. 2005. *A unified approach to nasality and voicing*. Berlin and New York: Mouton de Gruyter.

Nasukawa, Kuniya. 2014. Features and recursive structure. *Nordlyd* 41.1. *Special issue on features*, ed. by Martin Krämer, Sandra-Iulia Ronai and Peter Svenonius, 1–19.

Nasukawa, Kuniya. 2015. Recursion in the lexical structure of morphemes. *Representing structure in phonology and syntax*, ed. by Marc van Oostendorp and Henk van Riemsdijk, 211–238. Berlin/Boston: Mouton de Gruyter.

Naukawa, Kuniya. 2016. A precedence-free approach to (de-)palatalisation in Japanese. *Glossa: A Journal of General Linguistics* 1(1).1–21. DOI: http://dx.doi.org/10.5334/gjgl.26.

Nasukawa, Kuniya. 2017a. The phonetic salience of phonological head-dependent structure in a modulated-carrier model of speech. *Beyond markedness in formal phonology*, ed. by Bridget Samuels, 121–152. Amsterdam: John Benjamins.

Nasukawa, Kuniya. 2017b. The relative salience of consonant nasality and true obstruent voicing. *Sonic signatures*, ed. by Geoff Lindsey and Andrew Nevins, 145–162. Amsterdam: John Benjamins.

Nasukawa, Kuniya and Phillip Backley. 2015. Heads and complements in phonology: A case of role reversal? *Phonological Studies* 18, 67–74.

Nasukawa, Kuniya and Phillip Backley. 2017. Representing moraicity in Precedence-free Phonology. *Phonological Studies* 20, 55–62.

Nasukawa, Kuniya and Phillip Backley. 2018. |H| and |L| have unequal status. *Phonological Studies* 21, 41–48.

Nasukawa, Kuniya, Phillip Backley, Yoshiho Yasugi and Masatoshi Koizumi. 2019. Challenging universal typology: Right-edge consonantal prominence in Kaqchikel. *Journal of Linguistics* 55(3), 611–641. https://doi.org/10.1017/S0022226718000488

Ohala, John J. and Haruko Kawasaki-Fukumori. 1997. Alternatives to the sonority hierarchy for explaining segmental sequential constraints. *Language and its ecology: Essays in memory of Einar Haugen* (Trends in Linguistics. Studies and Monographs, Vol. 100), ed. by Stig Eliasson and Ernst Hakon Jahr, 343–365. Berlin: Mouton de Gruyter.

Ohala, John J. 1992. Alternatives to the sonority hierarchy for explaining segmental sequential constraints. *CLS: Papers from the parasession on the syllable*, 319–338.

Onuma, Hitomi and Kuniya Nasukawa. 2020. Velar softening without precedence relations. *Morpheme-internal recursion in phonology*, ed. by Kuniya Nasukawa, 201–229. Boston and Berlin: Mouton de Gruyter.

Snider, Keith and Harry van der Hulst. 1993. *The Phonology of tone: The representation of tonal register*, ed. by Harry van der Hulst and Keith Snider, 1–27. Berlin and New York: Mouton de Gruyter.

Traunmüller, Hartmut. 1994. Conventional, biological, and environmental factors in speech communication: A modulation theory. *Phonetica* 51.170–183.

Traunmüller, Hartmut. 2005. Speech considered as modulated voice. Ms., Stockholm University.

Yip, Moira. 1980. *The tonal phonology of Chinese*. Ph.D. dissertation, Massachusetts Institute of Technology.