A Pseudo-parametric Typology at the Syntax-Prosody Interface[1]

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subTOC

Phonological phrasing famously echoes aspects of syntactic constituency but diverges as well, in ways that vary both within and across languages.

Compare the distinct treatment of nearly identical structures in Northern Bizkaian Basque and Tokyo Japanese, two languages with remarkably similar pitch accent systems (Basque: Jun & Elordieta 1997, Elordieta 1998, 2007, Selkirk & Elordieta 2010; Japanese: Kubozono 1988/1993, 1989, Ito & Mester 2020). The following examples, for which the structural analyses have been thoroughly argued, exhibit a minimal contrast.[2] Orthography: á = lexically accented.

(1) *Prosody of Syntactic* [*A*] *B*

a. [*A*] *B* → [*A*] *B* (N. Bizkaian Basque)

[[Amáyen]$_{XP}$ dirua]$_{XP}$ → [[Amáyen]$_{\varphi}$ dirua]$_{\varphi}$ *A's money*

amáya-gen money-abs

b. [*A*] *B* → [*A*] [*B*] (Tokyo Japanese)

[[okáyama-no]$_{\mathbf{XP}}$ sakana-to]$_{\mathbf{XP}}$… → [[okáyama-no]$_{\boldsymbol{\varphi}}$ [sakana-to]$_{\boldsymbol{\varphi}}$]$_{\boldsymbol{\varphi}}$… *O's fish and…*

okáyama-gen fish -and …

The posited Basque prosody (1a) mirrors the syntax exactly, while Japanese (1b) augments it with a syntactically unmotivated phrase containing the prosodic word *B*.

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[1] We thank Junko Ito, Nick Kalivoda, and Armin Mester for much helpful discussions of earlier drafts. This section began as Alber & Prince 2016, 2017, based on the 2015 version of Ito & Mester's paper. For further details of the background theory, see Alber & Prince (2021), which forms Ch. 1 of Alber & Prince (in prep.).

[2] Examples from Ito & Mester (2020:254) and Selkirk & Elordieta (2010:3). See these works for discussion and deeper citation.

In addition, there can be different outcomes for the same input structure within a single language. Tokyo Japanese also shows prosodic $[A\ B]_{\varphi}$ from syntactic $[[A]_{XP}\ B]_{XP}$ when word *A* does not bear a lexical accent.

(2) Japanese $[A]\ B \rightarrow A\ B$

$[[\text{hiroshima-no}]_{XP}$ sakana-to$]_{XP}$ … → [hiroshima-no sakana-to$]_{\varphi}$… *H's fish and…*

hiroshima-gen fish -and …

The Japanese case, along with the analysis of it developed in Ito & Mester (2020), will provide key empirical groundwork for the typology studied in this section.

If we imagine syntax handing off to phonology in a strictly componentialized arrangement, then a candidate $\langle S_j{:}\Phi_k\rangle$ will associate an input syntactic *constituency* S_j with an output *phrasing* Φ_k on a fixed string of words.[3] A variety of different streams of information influence the outcome, interacting along faithfulness-markedness lines. The Ito & Mester analysis is particularly striking in the range of factors uncovered and integrated in the typology.

Faithfulness-type criteria monitor the input-output (IO) relations within a candidate, measuring the extent to which the input and output structures differ.[4] Two distinct species of structure are at play, grouping and the naming of groups. Categorically, on the naming side, syntactic *levels* correlate with the *levels* of a purely prosodic hierarchy. For example, in the work we will draw on, the *prosodic phrase* φ is asserted to be the correlate of syntactic XP, and the *prosodic word* ω is the correlate of syntactic X, to use a familiar nomenclature, with no variety allowed in choice of level. Structurally, with the level correlation universally fixed, faithfulness-type criteria are sensitive to how elements are differently *grouped* in the two associated representations, with much variation observed.

Thus, syntax might show an XP-within-an-XP structure like [[*A B*] *C*], branching on the left, while prosody might unfaithfully parse the same string into a prosodic-phrase-within-a-prosodic-phrase as [*A* [*B C*]], branching on the right.[5] Fully bracketed and labeled, we have:

syntax: $[\ [A\ B]_{XP}\ C]_{XP}$ prosody: $[A\ [B\ C]_{\varphi}\ ]_{\varphi}$

Among the divergences between the two, note that the output lacks the input grouping [*A B*] and the input lacks the output grouping [*B C*]. Thus, in the transit between syntax and prosody, the input constituent [*A B*] has vanished and the output constituent [*B C*] has come into existence.

[3] For evidence that in the broader scheme of things, phonology can directly drive syntactic choices, see e.g. Zubizarreta (1994, 1998) and, within OT, Samek-Lodovici (2005, 2015). Richards (2017:98) explicitly "assume[s] Match Theory" and therefore implicitly OT, placing him in this line of work as well.

[4] The relation to faithfulness and correspondence is explicitly recognized in Selkirk (2011:451), who notes that "Match(α,π) = [S-P faithfulness]," where "Match(α,π)" is a schema for match-theoretic constraints.

[5] See e.g. Prince (1980:521-530), Ladd (1986, 1988), Ito & Mester (2007, 2009, 2013), Martinez-Parício & Kager (2015), for recursion at various levels of prosodic structure. See Ito & Mester (2020:252) for further references.

This is analogous to the faithfulness breaches of deletion and insertion in segmental phonology, as noted by Selkirk (2011:451).

In contrast with S-Φ faithfulness, the relevant *markedness* constraints focus only on the prosodified output Φ. They may look for penalized structural configurations within the shape of the phrasing itself; or they may respond to the relationship between some phonological entity, often tonal or prominential, and the position it occupies in the phrasing. Prototypical structural criteria, for example, monitor *binarity* of nodes in various ways,[6] penalizing such configurations as [*A*] and [*A B C*], while others oversee relations among the categories, such as how the hierarchy of levels is to be respected as the nodes descend from the root (e.g. strict layering: Selkirk 1984:26; weak layering: Ito & Mester 1992/2003, level-equality of sisters: Myrberg 2013). In the empirical background of the typology examined here, the two phonological (as opposed to structural) factors at play are lexical accent and the surface distribution of low tone.

Where many sources of information contend, as here, the facts will rarely announce their own analysis. Equally, in a theory where phonetics emerges from structure and structures emerge from interactions between informationally-circumscribed constraints, as here, it is rarely obvious how a given set of premises analyzes a domain of facts, or even that it does, or that it does so unambiguously. Thus a formal-typological methodology, of the sort pursued here, is all but unavoidable.

2.1.1 Syntax, Prosody, and SP2

The system that we will study is abstracted from the work of Junko Ito and Armin Mester. With special focus on the role of recursion, continuing the program of Ito & Mester (2007, 2009, 2013), they examine in "Match Theory and Prosodic Wellformedness Constraints" (2020, henceforth *MTP*) an OT system that simultaneously evaluates prosodic structure from the distinct perspectives of phonology and syntax-to-prosody relations. From their stance, which views S-Φ relations within the "Match Theory" of Selkirk 2011, phrasing is meant to follow syntactic constituency up to the impingements of various essentially phonological constraints, which in this case will be sensitive to node binarity, lexical accent, and the span of low tone. We preserve Ito & Mester's factual base and candidate sets, while introducing a measure of simplifying abstraction by focusing on a single syntactic pattern and encapsulating results from the interacting nonstructural components.

[6] On the role of binarity in *foot structure*, see for example Prince (1980:525*ff*), McCarthy & Prince (1986), and many others subsequently. For its role in higher-order prosody, see e.g. Inkelas and Zec (1995) and others including the overview discussions in Selkirk (2011), and Elfner (2012: Ch. 4.2, 149*ff*.). See fns. 11 and 12 below for references to work on various other aspects of binarity. See Bellik, Bellik, & Kalivoda (2015-21) for the web-app environment SPOT that computes full syntax-prosody candidate sets under user-designated assumptions about binarity, matching, and alignment, among other properties relevant to syntax-prosody mapping.

This work therefore takes its place in the progression of ideas from Liberman (1975), the purest of match theories, in which intonational phonology connects to an exact but relationally-relabeled image of syntactic structure, through Chen (1984/87) and Selkirk (1986), generalized in McCarthy & Prince (1993), in which phonology sees just one edge or the other of a syntactic domain at a time, to Truckenbrodt (1995, 1999) where both left and right edges may be seen simultaneously, to the proposal of Selkirk (2011) that departures from perfect syntax-prosody *match* can be derived under OT without asking anything more of syntactic and prosodic structure at specified levels than that they be, in essence, *the same*.

MTP studies certain left-branching syntactic structures of 2-4 words in length, drawing data from Tokyo Japanese and Northern Bizkaian Basque, where single-word syntactic units are parsed into a structure, maximally [[[[w] w] w] w], which figures as input to the syntax-prosody map. The motivating evidence that we will incorporate into our discussion is drawn from the tonology of Tokyo Japanese, which has been well studied since the early days of Generative Phonology (starting with McCawley 1968) and has received particular impetus from the deep work of Kubozono (1988/93, 1989), who established the key facts and generalizations that drive modern work.

Based on MTP, we narrow attention to just the two-word input, yielding a system we call SP2 (Syntax-Prosody, length 2). SP2 is a proper subsystem of MTP, and though it is simpler than the whole, it is sufficiently rich to stand instructively on its own. It exhibits the range of diverse factors that enter into contention in full MTP, as well as the inferential character of the analyses that result and the unexpected typological structure they yield.

In addition, it proves to be of considerable formal interest. The property analysis of SP2 is built entirely from *elementary properties* of the form A<>B, where A and B name individual constraints rather than (nontrivial) classes as in the typologies of Ch. 1. The resulting typology belongs to a type that we will call *pseudo-parametric*, in that from n elementary properties, we obtain 2^n grammars, with every property taking the form C_k<>B, $1 \leq k \leq n$, where B is the same constraint in all properties and C_k varies through the rest of the constraint set.

2.1.1 Preliminary

To see what's at stake, consider the single syntactic structure carried by all SP2 inputs:

(1) Left-branching syntax

a. tree:

```
   YP
  /  \
XP    Y
 |
 X
```

b. bracketed: $[[\ X]_{XP}\ \ Y]_{YP}$

The relevant syntax-phonology relations are entirely determined by the *level* of the relevant nodes, not the category. Therefore, it is legitimate to simplify the input to the following, where 'w' and 'P' mark the two levels. Numbers could be used in their place, say 1 and 2, but in the present case, there is no need for their richness, and we use the more mnemonic w, P descriptors. To emphasize that P and w denote *levels* not substantive categories, we display the numerical representation this one time.

(2) Syntax: left branching

a. Tree:

```
   P              ⟨2⟩
  / \            /   \
 P   w    =   ⟨2⟩   ⟨1⟩
 |             |
 w            ⟨1⟩
```

b. Brackets: $[[\mathrm{w}]_{P}\ \ \mathrm{w}\ ]_{P}$

c. Concise: .[w] w.

The reduced notation on the far right in (2)c takes advantage of the fact that there's only one level of higher-order constituent in sight, namely P = ⟨2⟩, and therefore omits to name it. Since all candidates are rooted at level P, the outer brackets are typographically de-emphasized.

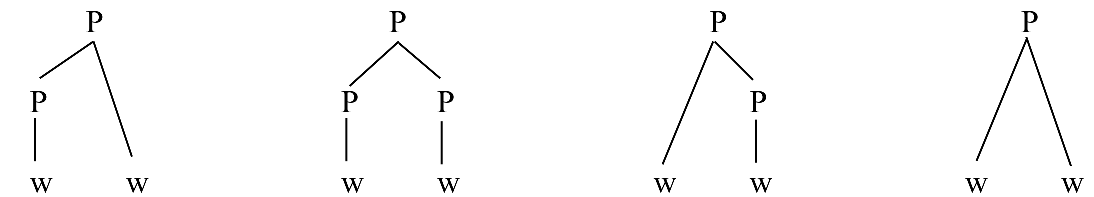
Within the phonology, the *prosodic phrase* (aka *phonological phrase*), φ in MTP, stands as the cognate of XP while the *prosodic word* (aka *phonological word*), ω in MTP, is the cognate of simple X.[7] Because we are focusing on the structural aspects of SP2 rather than theory of syntax-prosody per se, we allow ourselves to deviate somewhat from the standard notation. Since only *level* matters, it is legitimate to treat syntax and phonology *identically*, using P for the entities {φ, XP} at level 2 and w for {ω, X} at level 1, leaving further node content to the ecology of the domain in which a given structure finds itself.[8] Under this conception, the one syntactic input is $[[\mathrm{w}]_{P}\ \mathrm{w}]_{P}$ = .[w] w. and the admitted phonological *outputs* in SP2 from the single input will be the following, with the concise notation shown beneath the trees.

[7] In his valuable overview article, Ishihara (2015:517, table 1) usefully correlates the various names of these and related entities across different strands of work.

[8] In the present context, this correlates helpfully with input vs. output status.

(3) Possible Prosodic Phrasings in SP2 of the syntactic input [[w]P w]P = .[w] w.

a. b. c. d.



.[w] w. .[w] [w]. .w [w]. .w w.

The prosodic phrasing exhibits all the possibilities except vacuous recursion, which would admit structures [P P]. Notable structural enrichments allowed in potential outputs include the appearance of a second P under the root in (3)b and the disappearance, as it were, of the embedded initial input P in (3)c and (3)d.

The basics of the syntax-to-phonology mapping problem in SP2 may now be displayed. The sole structural input .[w] w. comes out in four different ways. In this, we follow the MTP candidae sets closely.

(4) S-Φ maps in SP2

syntactic input	.[w] w.
phonological outputs	.[w] w.
	.[w] [w].
	. w [w].
	. w w.

The analytical challenge is to determine the conditions under which the various outputs appear. Ito & Mester discern three distinct types of information at work: structural, lexical, and tonological. It is instructive to see how they fit together.

1. **Structural**. To link syntax to phrasing, we need to be able to correlate a node in one tree with a node in another. Evaluating unrestricted tree-to-tree *matching* has daunting complexities, but the narrowness of the syntax-prosody relation in general and of SP2 in particular make life quite manageable. Elfner has developed an attractive solution to the node-relation problem as it appears in the present circumstances:

> [MATCH-PHRASE is] defined in terms of correspondence between sets of terminal nodes dominated by syntactic nodes and their phonological exponents, which are dominated by prosodic nodes. Elfner (2012:26).

Broadly put, nodes may *match* only if they dominate the 'same' terminal string. We render the notion here by extending correspondence to all nodes, positing that a node in one tree *corresponds to* a node in another whenever the nodes dominate corresponding terminal strings.[9] A constraint of the 'Match' type then penalizes the failure to *have* a correspondent node of the appropriate level, just as familiar f.max and f.dep penalize lack of correspondent rather than some kind of mismatch between correspondent items.

With this understanding, two directions of matching can be observed, input-to-output and output-to-input. Syntax-to-prosody matching parallels the familiar faithfulness constraint f.max, which penalizes deletion. In SP2, this comes down to nothing more complicated than the question of whether the first w of the string is bracketed as [w], as it is in /.[w] w./, the one syntactic input. We'll call this *Max*-type constraint sp.Mat (abbreviating Ito & Mester's MATCH-XP), where the 'sp' prefix signals *syntax→prosody* directionality. Observe that sp.Mat does *not* detect the presence of 'epenthetic' bracketing as in the output .[w][w]., where the prosodic phrase enclosing the second w has no correspondent in the syntactic input. This relation would be monitored by a *Dep*-style constraint *ps*.Mat, which is not present in the systems studied in MTP.

Of the outputs listed in (4), the first two are therefore perfect in s-to-p matching (penalty: 0), while the second two are not (penalty: 1).

(5) Making a good match: penalties on sp.Mat

Input	Outputs	Penalty
.[w] w.	.[w] w.	0
	.[w] [w].	0
	. w [w].	1
	. w w .	1

Thus, despite the fact that matching between general trees can incur any number of violations, in SP2 the constraint sp.Mat functions as boolean, assessing penalties {0, 1}. The constraint can be sketched concisely as follows, using '∼' for correspondence and the addition assignment operator +=,[10] and, as usual, '∈' somewhat loosely for the relevant sense of ''belonging to'.

(6) sp.Mat. Let k = (T_1, T_2). For each $\mathbf{n} \in T_1$, if $\nexists \mathbf{m} \in T_2$ s.t. $\mathbf{n} \sim \mathbf{m}$, then sp.Mat(k) += 1.

[9] Two strings will *correspond* if all the elements of each string are individually in correspondence.

[10] The 'addition assignment operator' += is borrowed from programming languages. The expression x+=y means 'add y to x and assign the resulting value to x', thereby condensing x ← x + y.

The second structural criterion is *binarity*, perhaps the fundamental markedness consideration encountered throughout prosody. Binarity has a number of senses in general, though in SP2 these are all neutralized. In the larger scheme of things, notions of binarity are involved in penalizing constituents that are the wrong size: [11]

- too small: unit constituents: [X].
- too big: ternary and longer s: [X Y Z …].

And in addition, binarity may be sensitive to different aspects of hierarchical structure. [12]

- the immediate children of a node
- the terminals it dominates.

In SP2, there are no ternary or longer constituents, and every node P has the same number of terminals as branches. Therefore, we can safely write the binarity constraint in SP2 as penalizing general unary constituents [X]. The "m" of m.Bin signals that it is a markedness constraint, scanning only the output.

(7) m.Bin. $*[X] \in out$, $X \in \{w, P\}$.

2. **Phonology in Structure**. Many languages distinguish between items specified for lexical accent and items accentually unspecified, which receive their prosody predictably. In MTP, and more particularly in the typology of SP2, this distinction affects the optimality of the available phrasing patterns, and must therefore be part of what is admitted and represented. In the broader world, lexical accent is a phonological or diacritic property of syllables or moras or the like;[13] here, as in MTP, we regard the *word* as an opaque atom, rather as we took the *syllable* to be atomic in the typologies of Ch. 1. The entities of level 'w' come in two types, using Ito & Mester's notation:

- a (lexically accented)
- u (lexically unaccented)

We go one step further and for our purposes take a and u to be essentially features of w, identifying the lexical word with the syntactic node X that dominates it. This distinction engenders two notable asymmetries among optima in MTP, arising ecologically from properties of a that u lacks. One involves the relationship between accented a and structural position.

[11] Elfner (2012:153, fn. 61) cites Hewitt (1994), Mester (1994), Selkirk (2000), Ito & Mester (2006) for the distinction between minimal and maximal binarity. See Selkirk (2011:469) for the terms 'BinMax and BinMin', referring to Ghini (1993) and Inkelas & Zec (1995) for their role in supra-foot prosody.

[12] For the distinction between sensitivity to the children of a node ('branches'), or to its terminal content ('leaves'), see discussion in Elfner (2012: ch. 4.2, p. 193), Kalivoda (2018: ch. 4, p.91), Bellik & Kalivoda (2018), and Bellik & van Handel (to appear). Bellik, Ito, Kalivoda, & Mester (to appear) posit both versions in the systems they study. The web-app SPOT (Bellik, Bellik, & Kalivoda 2015-2021) allows evaluation of minimal and maximal binarity as well as 'branch-binarity' and 'leaf-binarity', to use the terms of Bellik & Kalivoda (2018).

[13] Further interesting formal questions arise about how accent is specified lexically and how such specification is referred to phonologically. For example, syllables are often assumed absent from the lexicon, and, though accent is local, whole words are spoken of as 'accented'. See Haraguchi (1977), Poser (1985) and others for relevant discussion and proposals.

The other involves the tonology of a and its knock-on effect on the prosody of a following u, which we take up in 2b below after concluding the structural discussion.

2a. **Accent and Position**. Ito & Mester propose that lexical accent is tropic to *head* position in prosodic structure, as embodied in a constraint they call ACCENTASHEAD, which we will shorten and type-mark to m.AxHd. In SP2, when the head of the whole two-word P is initial, this favors the candidate phrasing .[w] **[a]**. over .[w] **a**., hyperarticulating the input syntactic constituency to provide a phrase of which **a** is the head, namely the one that encloses it.

For SP2.Con to use this idea, SP2.Gen must recognize and represent a distinction between *head* and *nonhead* position in prosodic structure. To bring this notion into play, let us first affirm the following general doctrine of headship in prosody,[14] which we believe to be non-innovative.

(8) General Headship

a. *Headedness*. Every nonterminal constituent has one child designated as its *head*.

b. *Inequality*. If a constituent has children of different levels, only those of the highest level may be heads.

c. *Edge Location*. Heads occur at the left or right edge of a constituent.

These principles determine head location for most, but not all, of the output cases.

- [w]P : When a phrase contains a single word, it is the head, by *Headedness*.
- In .P w. and .w P., the node P is the head of the whole, by *Inequality*.
- In .P P. and .w w., *either* node may be head, by *Edge Location*.

In general, there is need to recognize both left- and right-headed versions of 'balanced' prosodic constituents — those consisting of nodes at the same level — for example, iambic and trochaic feet, as in Ch. 1. In the specific case of SP2 and MTP, however, headship is only detected by m.AxHd, which has no sensitivity to position. Augmenting SP2 with head-location constraints would lead to a richer super-systems of SP2, and in the interests of maintaining focus on the MTP interactions, we set this alternative aside.[15] In addition, to avoid a pointless blow-up of left-headed/ right-headed candidate pairs with identical violation profiles, which are therefore identical in OT behavior, we limit head location in all perfectly balanced constituents. We declare that in forms shaped .X X., as in .P P., .a a., or .u u., the head can for purposes of SP2.Gen be only the *leftmost* element. This maneuver has no effect on the structure or

[14] Of these, *Inequality* is definitely not a principle of syntactic headedness.

[15] Installing head-position constraints does raise the tantalizing possibility of eliminating the constraint that specifically targets unarity, along the lines of the foot-type constraints of Ch. 1 and throughout, whereby both m.Iamb and m.Trochee penalize unary feet for being headed on the wrong side. The same applies here: since [X] is both right- and left-headed, it is penalized by both anti-left (= pro-right) and anti-right (= pro-left) constraints. Other forms of left/right constraints raise other possibilities. There is a world to explore out there.

predictions of the system, and has the virtue of increasing access to the patterning under scrutiny.[16]

(9) *Equality Default* (SP2).

A constituent X X, where X is uniformly P, a, or u, is left-headed.

Orthographically, w-level heads will be capitalized as A and U. P-level heads will not be marked, as their headship status plays no role at all. This allows for a concise formulation of the relevant constraint.

(10) m.AxHd. *a

Summarizing, the effects of headship on the status of elements u and a are these:

- Headship assignments [A] and [U] are definitionally forced by *Headedness* (8)a.
- Left-headed .U u. and .A a. are allowed by SP2.Gen. Right-headed versions are not (9).
- Both .U a. and .u A., as well as both .A u. and .a U. are allowed as outputs.
- The accented nonhead a may licitly appear, but incurs a penalty from m.AxHd (10).

The status of P as child of the root is also fully determinate:

- P is the head in .P w. and .w P. as definitionally forced by *Inequality* (8)b.
- The first P of .P P. is declared the head in SP2.Gen.

Inequality (8)b eliminates a contrast between e,g, .P w. (left-headed root) and .P W. (right-headed root). Admitting .P W. in SP2.Gen would most naturally be accompanied by positing a head-position constraint to control it, amplifying SP2.Con, which we eschew.

The upshot is a severe limitation on heads, displayed in the following table of admitted parses, which run across the row for each input. All candidates recognized by SP2.Gen are included. Harmonically bounded forms are greyed out and starred.[17]

[16] Since left- and right-headed versions of balanced constituents X X turn out, in SP2, to receive exactly the same violation profiles, they are indistinguishable with respect to OT evaluation. Thus, the left-headed version that we have settled on is a legitimate *representative* of the equivalence class containing both.

[17] Details of bounding are described in the text below ex. (14) when all the pieces of SP2 have been assembled.

(11) Admitted w-level Prosodic Headship Patterns in SP2.Gen, given the prosodic parse

↓ Inputs /.P w./	Prosodic parses →				
	.P w.	.w P.	.P P.	.w w.	
/[a] a/	.[A] a.	*.a [A]	.[A] [A].	.A a.	
/[u] u/	.[U] u.	*.u [U].	*.[U] [U].	.U u.	
/[a] u/	.[A] u.	.a [U].	.[A] [U].	.A u.	*.a U.
/[u] a/	.[U] a.	*.u [A].	.[U] [A].	*.U a.	.u A.

Headship at the root level is left unnotated in .P P., where it is inconsequential. In .w w. , only the headship in parses of **/u a/** and **/a u/** is allowed to vary, as seen in the rightmost column of the table. But even here, there is no contrast in optima since .a U. from /a u/ and .U a. from /u a/ turn out to be harmonically bounded over the constraints of SP2.Con.[18]

Thus, every prosodic parse of elements a, u is associated with exactly one head location among the optima. This is sufficient to support the role of headship in SP2, echoing Ito & Mester's use of the notion.

2b. **Tonological**. The a/u distinction has an associated tonology in the richer worlds where a/u are granted internal structure. In MTP, such tonology is felt through its impact on the prosodic parse. Though substantively inspired by the specific facts of Tokyo Japanese, its essentials are far from idiosyncratic. Cross-linguistically, it is not uncommon to find that the accented syllable in a word a carries a tonal fall HL, and, independently, that the presence of L has notable further consequences, initiating downstep and/or perseverating until it meets another specified tone or a structural barrier. Thus, post-accentually, a lowered span is commonly encountered.

In this regard, compare the Northern Bizkaian Basque and Tokyo Japanese examples cited in (1) above, with outer brackets omitted here for clarity.

N. Bizk. Basque: [Amáyen]$_\varphi$ dirua *Amaya's money*
Tokyo Japanese: [okáyama-no]$_\varphi$ [sakana-to]$_\varphi$ *Okayama's fish*

The input syntax .[w] w. is shared by both examples and only the relevant posited prosodic phrasing is given. In each case, the H of the lexical accent HL attaches itself to the vowel spelled á and the L to what follows. In Basque the second word exhibits the lowering effect of the first word's accent. In Japanese, however, the second word takes on the characteristic tonology of a (Japanese) prosodic phrase φ, an initial tonal rise, which protects it from the accentual L.

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[18] The constraint m.AxHd (10) disfavors both *.**a U**. and *.**U a**. with respect to their possibly optimal competitors .**A u**. and .**u A**., respectively, and no constraint of SP2 that we have seen so far, and none that we shall see, otherwise distinguishes them from their alternatives. Notice also that none of these 4 shows a good match, which requires a unit P = [w]$_P$ in initial position. But sp.Mat is just one constraint among several, and satisfying it necessarily incurs a penalty from m.Bin, whereas .**A u**. and .**u A.** are as binary as it gets. Relatedly, note that .**a** [**U**]. and .[**A**] [**U**]. contrast in sp.Mat but differ in the opposite way on m.Bin, so that neither bounds the other.

With this kind of HL realization of lexical accent, a word u in the frame …a u…, because it lacks intrinsic specification, will typically emerge as *entirely low-toned*, in the absence of further interventions. Following a line of analysis developed and supported in their earlier work,[19] Ito and Mester argue that this effect is deprecated by a family of constraints against extended spans of low tone. They therefore propose a constraint of this character that penalizes "each fully L-toned" prosodic word (Ito & Mester 2013), which they name NoLapse (MTP:5). If lowness implies lack of salience, it may be that a *low word* runs afoul of the widely attested tendency for prosodic categories, and prosodic words in particular, to host a prominence of some sort. Tightening our focus to the type of system under scrutiny, we will abbreviate the constraint to m.NLW, mnemonic for *No Low Word*.[20]

The structural effect of m.NLW emerges tonologically from the following interaction: the rightward range of an accentual L is halted by the appearance of an initial phrase-edge.

- Parses .[A] u. , .A u., and .a U. render /u/ a *low word*.
- Parses .[a][U]. and .a [U]. protect /u/ from being subsumed in the spread of the accentual L (of the accent HL) implicit in /a/. These two parses encase /u/ in *syntactically unmotivated* structure. Thus does tonology and the threat of tonology cash out as phrasing.

In Tokyo Japanese, the success of this explanation follows inferentially from another structure-related intonational phenomenon: a prosodic phrase P begins, in the now standard construal, with a rise LH. Thus, given /a u/, the span of the accentual L associated with a cannot enter a prosodic phrase [U], because [U] is defended by its own (derived) tonology: the P-initial rise.

In constructing SP2, we will encapsulate the results of the relevant tonology rather than aiming to incorporate its infrastructure and interactions. Here again, we put ourselves in a position like that of Plato's cave dwellers, who (concatenated face-first to the wall) see only a diminished projection of things as they are. We have the advantage of knowing what's out there and can deliberately choose how we contract our view, leaving the way clear for future expansion. Explicit tonology will therefore be excluded from SP2, but we recognize the *low word* as an output entity, notated o (and O when a head), a species of w deriving from u, whose distribution will be controlled *ad hoc* in SP2.Gen. Thus, SP2 does not aim to replicate the Ito & Mester insight into prominence-driven phrasing, but instead retains a pointer to it.

(12) m.NLW. *o, O

Having set SP2 in its linguistic context, we now turn to the typology itself.

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[19] See Ito & Mester (2013), ex. (27) and discussion following it, where the relevant constraint is identified as "part of a family of related constraints" governing low-tone spans, manifest for example in the accentuation of Ancient Greek.

[20] If lowness implies lack of salience, it may be that the *low word* runs afoul of the widely attested tendency for prosodic categories, and prosodic *words* in particular, to host a prominence of some sort.

2.1.2 The System SP2

Here we give a concise account of SP2 = ⟨SP2.Gen, SP2.Con⟩, built from the commitments laid out in the previous section. Phrasal notation is as in 2.1.1 above, whereby [X] represents a constituent of level P, either syntactic or phonological, with outer brackets (which are always present) reduced to '.' for visual clarity.

SP2.Gen

G.1 Candidate. A *candidate* is an ordered triple ⟨Σ, Φ , cor(Σ, Φ)⟩, where

- Σ is a syntactic tree (the *input*)
- Φ is a prosodic tree (the *output*)
- cor(Σ, Φ) is a correspondence relation between their nodes.
- Σ and Φ have correspondent terminal strings.

Element Φ is called a *prosodic parse* of (the terminal string) of Σ.

G.2 Candidate Set. A *candidate set* consists of all candidates in which a given syntactic structure Σ is associated with a licit prosodic parse of Σ.

Conditions G.1 and G.2 apply broadly to many types of syntax-prosody systems. We now move to the specifics of SP2.

G.3 Input. The syntax of SP2 recognizes two node levels, X^0 = X and X^1 = XP, which we notate as w and P, respectively, dropping mention of the category X, which is not relevant. The concise expression .[w] w. notates the sole level-labeled syntactic input $[_P[_P$ w] w].

We conflate category X^0 = w with the word that it *strictu sensu* dominates.

G.4 Output (Prosodic Parse). The output prosody of SP2 is limited to the following four structures, given in terms of bracketting labeled by level only (right) or reduced by typographical convention (left).

Concise	Full
. w w.	$[_P$ w w]
.[w] w.	$[_P[_P$ w] w]
. w [w].	$[_P$ w $[_P$ w]]
.[w] [w].	$[_P$ $[_P$ w] $[_P$ w]]

Each licit structure consists of a *prosodic phrase* of level P (*i.e.* level 2) which dominates either other level P elements or *prosodic words* of level w (*i.e.* level 1). All contain outputs with exactly two terminal w's.

The following grammar, which respects 'weak layering' (Ito & Mester 1992/2003), spells out the parsing possibilities. The notation X|Y means 'freely pick exactly one of X or Y."

$P \rightarrow w|P\ w|P$

$P \rightarrow w$

G.5 Lexical Classes. Two (crypto-tonophonological) distinctions are posited.

a. **Accented/Unaccented**. Input words w are 'accented' (a) or 'unaccented' (u).

b. **Low word/ nonlow word**. There are two subspecies of unaccented words in the output: the 'low word' (o, O) and the 'nonlow word' (u, U). The input element /**u**/ thus has two types of output exponents, 'low' and 'non-low'.

G.6 Correspondence between trees Σ and Φ

a. A terminal node of Σ corresponds to the one in Φ in the same serial position.

b. A node w may correspond only to a w of the same input class, accented or unaccented, the latter of which includes both 'low' and 'non-low' as outputs.

c. A node N (of level P) in Σ corresponds to a node N′ (of level P) in Φ if and only if each w in the terminal content of N *corresponds* to a w in the terminal content of Φ.

We write $N \sim N'$ in this case. We write $N \nsim N'$ for 'N does not correspond to N′'. Note that conditions (a) and (b) render the intuitive notion "Σ and Φ have the *same* terminal string'. Condition (a) is the same as the one in Kalivoda (to appear, exx. (9c)): "For an input tree *S* and an output tree *P*, a correspondence relation holds such that the *n*th terminal node of *S* corresponds to the *n*th terminal node of *P*." Condition (c) lifts the notion of correspondence to the non-terminal level and thereby renders Elfner's notion that satisfaction of the constraint MATCH-PHRASET, i.e. a succesful *match*, is obtained when for every XP in the input representation, there is a φ in the output that "exhaustively dominates all and only the phonological exponents of the terminal nodes" of that XP (Elfner 2012:28).[21]

G.7 Headship in Prosodic Phrasing

a. *Headedness*. Exactly one child of output P is designated as its prosodic head.

b. *Inequality*. If a prosodic constituent has children of different levels, only those of the highest level may be the head. Thus, in .P w. and .w P., only P may be the head of the root.

c. *Location*. The prosodic head of P occurs at either the left edge or the right edge of P. When child nodes are categorically identical, as in .P P., .a a., .u u., the head is the *leftmost*.

Head status is notated by capitalization: thus, A and U are written when lexical /a/ and /u/ appear as head of a prosodic phrase P. In structures .P P., the (initial) head isn't marked, because its position plays no role. Thus, by G.7.c, the admitted outputs for twin pairs are written .P P., .A a. and .U u. .

---

[21] Selkirk (2011:451), ex.(20a), writes in terms of correspondence between edges. "Match (α, π) [= S-P faithfulness]. The left and right edges of a constituent of type α in the input syntactic representation must correspond to the left and right edges of a constituentof type π in the output phonological representation."

.

G.8 Positions of the Low Word. Lexical /u/ appears in the output as the *low word*, written o**,** or O if a head, when the following two conditions are met:

1) it is preceded by an accented word.
2) it is non-initial in P.

G.8 accepts Ito & Mester's explanation, but is a mere summary, or Platonic shadow, of the results of the tonal phonology that would come into play in a richer system.

SP2.Con

Four constraints are posited:

(13) **Con.SP2**

Constraint	Def. (Concise)	MTP name
m.AxH	*a	ACCENTASHEAD
m.NLW	*o, O	NOLAPSE
m.Bin	*[X], $X \in \{w, P\}$	MINIMALBINARITY-φ/ω
sp.Mat	*N: $N \not\sim M$, $N \in \Sigma$, $M \in \Phi$	MATCH-XP-TO-φ

Verbose:

m.AxHd: Each accented word not in head position incurs a penalty.
For a candidate $\mathbf{q} = \langle \Sigma, \Phi, \text{cor}(\Sigma, \Phi)\rangle$, m.AxHd($\mathbf{q}$) = $|\{\text{a} : \text{a} \in \Phi\}|$

m.NLW: Each unaccented word that is a 'low word' incurs a penalty.
For $\mathbf{k} = \langle \Sigma, \Phi, \text{cor}(\Sigma, \Phi)\rangle$, m.NLW($\mathbf{q}$) = $|\{w \in \{\text{o}, \text{O}\} : w \in \Phi\}|$

m.Bin: Each prosodic node that dominates a single element incurs a penalty.
For $\mathbf{q} = \langle \Sigma, \Phi, \text{cor}(\Sigma, \Phi)\rangle$, m.Bin($\mathbf{q}$) = $|\{N \in \Phi : N = [X]\}$

sp.Mat. In $(\Sigma, \Phi, \text{cor}(\Sigma,\Phi))$, each P-level node in Σ lacking a correspondent in Φ incurs a penalty.
For $\mathbf{q} = \langle \Sigma, \Phi, \text{cor}(\Sigma, \Phi)\rangle$, sp.Mat($\mathbf{q}$) = $|\{N \in \Sigma : \nexists M \in \Phi \text{ s.t. } N \sim M;\ M, N \text{ of level P}\}|$

2.1.3 The typology of SP2

The following table displays the assignment of penalties to all candidates admitted by SP.Gen. The csets cited therefore provide a valid Universal Support for the typology for the unarguable reason that they constitute exhaustively all the csets admitted by SP2.Gen. However, a *minimal* Support requires only csets 1-3 or csets 2-4. This may be shown by a straightforward calculation of the typologies that result from each of the various subsets of the full collection of csets 1-4. The same grammars will be obtained from the csets {1, 2, 3} and from the csets {2, 3, 4} as from {1, 2, 3, 4}, but any other subset will fail to produce the 8 language typology and its grammars.[22]

Candidates are arranged in order of ascending m.Bin violations (first constraint column), with equal violations arranged by performance on sp.Mat (last column). The six harmonically bounded forms are marked in pink.

(14) All SP2 candidates evaluated

#	input	output	**m.Bin**	**m.AxHd**	**m.NLW**	**sp.Mat**
1.1	/.[u] u./	.U u.				1
1.2		.[U] u.	1			
1.3		.u [U].	1			1
1.4		.[U] [U].	2			
2.1	/.[a] a./	.A a.		1		1
2.2		.[A] a.	1	1		
2.3		.a [A].	1	1		1
2.4		.[A] [A].	2			
3.1	/.[a] u./	.A o.			1	1
3.2		.a O.		1	1	1
3.3		.[A] o.	1		1	
3.4		.a [U].	1	1		1
3.5		.[A] [U].	2			
4.1	/.[u] a./	.u A.				1
4.2		.U a.		1		1
4.3		.u [A].	1			1
4.4		.[U] a.	1	1		
4.5		.[U] [A].	2			

The details of harmonic bounding fall out as follows. There is no collective bounding.

[22] In particular, cset 1 or cset 4 is necessary for distinguishing between the languages we call Ax.NL and M.Ax.NL.

- .u [U]. is bounded by .[U] u and also by .U u. (1.3 by 1.2 and by 1.1)
  1.3 and 1.2 share the m.Bin penalty, and 1.3 = .u [U]. adds a mismatch (*sp.Mat).
  1.3 and 1.1 share the sp.Mat penalty, and 1.3 adds an m.Bin penalty.
- .[U] [U]. is bounded by .[U] u. (1.4 by 1.2)
  They agree at 0 everywhere except on m.Bin, where they face off as 2 to 1.
- .a [A]. is bounded by .[A] a. and also by .A a. (2.3 by 2.2 and 2.1)
  2.3 and 2.2 share m.Bin and m.AxHd violations, and 2.3 adds a mismatch (*sp.Mat).
  2.3 and 2.1 share m.AxHd and sp.Mat violations, and 2.3 adds an m.Bin violation.
- .a O. is bounded by .A o. (3.2 by 3.1)
  They agree everywhere except on m.AxHd, where .a O. adds a gratuitous violation.
- .U a. is bounded by .u A. (4.2 by 4.1)
  They agree everywhere except on m.AxHd, where .U a. adds a gratuitous violation.
- .u [A]. is bounded by .u A. (4.3 by 4.1)
  Both carry a single mismatch (*sp.Mat), but 4.3 = .u [A]. also violates m.Bin.

The constraints sp.Mat, m.AxHd, and m.Bin are the ones involved in providing the extra bounding violations. The optima, then, are these:

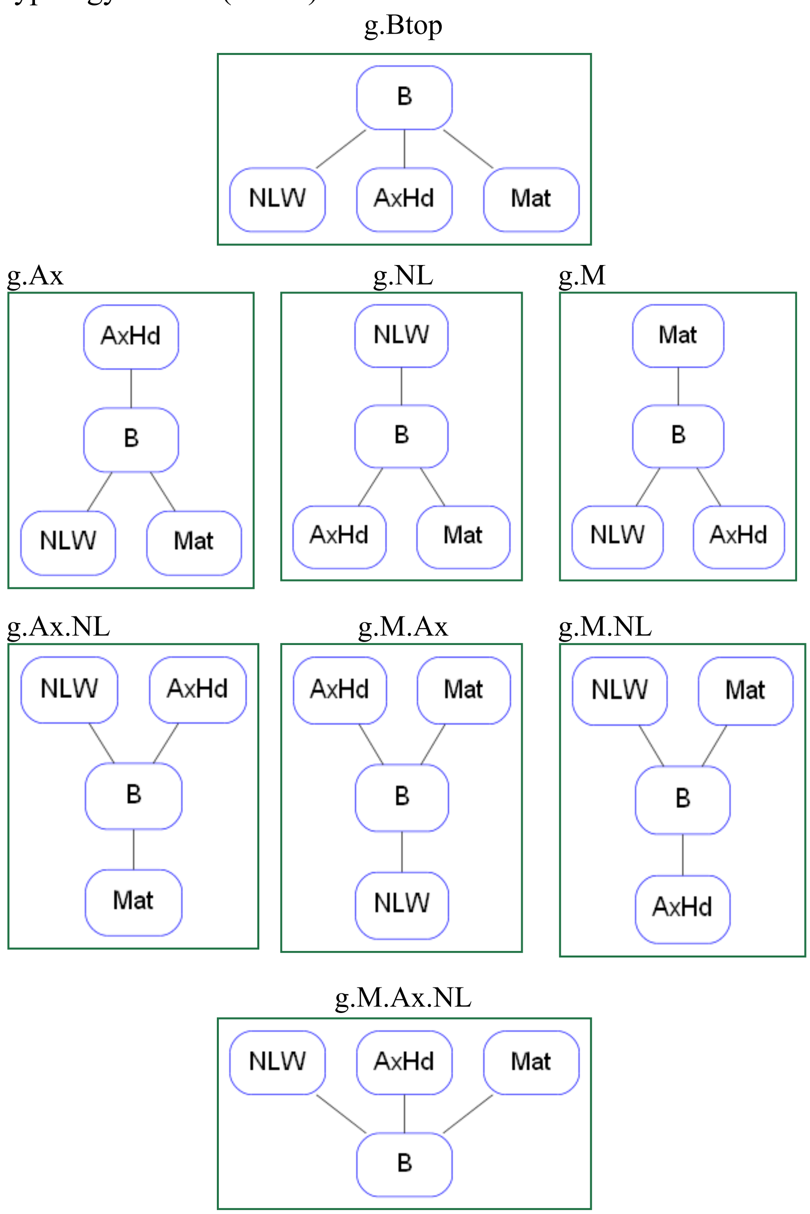
(15) SP2 optima

#	input	output	**m.Bin**	**m.AxHd**	**m.NLW**	**sp.Mat**
1.1	.[u] u.	.U u.				1
1.2		.[U] u.	1			
2.1	.[a] a.	.A a.		1		1
2.2		.[A] a.	1	1		
2.4		.[A] [A].	2			
3.1	.[a] u.	.A o.			1	1
3.3		.[A] o.	1		1	
3.4		.a [U].	1	1		1
3.5		.[A] [U].	2			
4.1	.[u] a.	.u A.				1
4.4		.[U] a.	1	1		
4.5		.[U] [A].	2			

Cset #1 from input /.[u] u./ gives us a property outright, namely m.Bin<>sp.Mat, but the others are more intricate. SP2 is a case where the intensional typology provides a clearer path into the structure of the extensional typology than contemplating csets and patterns of optima. We therefore begin by examining the 8 grammars of the system. Because all grammars are partial orders, they may be faithfully represented as Hasse Diagrams.

We mark grammars by the prefix ‘g’, For visual clarity in the diagrams, we engage in some transparent abbreviation: prefixes ‘m’ and ‘sp’ are omitted, and the fields in grammar names are shortened from the names of the constraints dominating m.Bin = ‘B’, with the exception of ‘Btop,’ which indicates that nothing dominates it.

(16) Intensional Typology of SP2 (Hasse)



It is evident that the typology derives entirely from the relation of the other constraints to m.Bin.

- In the first row, m.Bin — shown as ‘B’ — dominates all the others.
- In each grammar of the second row, exactly one of others dominates m.Bin.
- In the third row, each possible *pair* of the others dominates m.Bin.
- And in the last row, m.Bin *is dominated by* all three of the others.

In each case, any constraints that do not dominate B are dominated by it.

ERC representations of the grammars lead immediately to an analytical understanding of this pattern. To get maximal insight from them, it's useful to recall that any ERC with multiple L's can be exploded into an equivalent set of 'Primitive Ranking Conditions' (PRCs: Prince 2006/8:4) which have just one L per ERC. For example, g.Btop has just one ERC in its most concise representation, its 'Skeletal Basis' or 'MIB' (they are the same in this case).

(17) ERC representation of g.Btop

B	AxHd	NLW	Mat
W	**L**	**L**	**L**

This blows up to a logically equivalent set of three PRCs, which collectively say the same thing.[23]

(18) PRC grammar of g.Btop

B	AxHd	NLW	Mat
W	**L**		
W		**L**	
W			**L**

Expanding in this fashion the Skeletal Bases associated with the SP2 typology, we obtain the following PRC representations, which the reader may wish to check against the Hasse diagrams in (16).

[23] Where ERC (17) says "B dominates every member of the set {AxHd, NLW, Mat}," PRC set (18) says "B dominates AxHD and B dominates NLW and B dominates Mat."

(19) Grammars of SP2 as PRCs

g.Btop

B	AxHd	NLW	Mat
W	L		
W		L	
W			L

g.Ax

B	AxHd	NLW	Mat
L	W		
W		L	
W			L

g.NL

B	AxHd	NLW	Mat
W	L		
L		W	
W			L

g.M

B	AxHd	NLW	Mat
W	L		
W		L	
L			W

g.Ax.NL

B	AxHd	NLW	Mat
L	W		
L		W	
W			L

g.M.Ax

B	AxHd	NLW	Mat
L	W		
W		L	
L			W

g.M.NL

B	AxHd	NLW	Mat
W	L		
L		W	
L			W

g.M.Ax.NL

B	AxHd	NLW	Mat
L	W		
L		W	
L			W

From this display, it's easy to confirm that every grammar involves ranking relations between m.Bin and each of the others; that every relation involving m.Bin appears; and that nothing else does. The entire set of grammars may be summarized in one tableau, writing $\overline{X}$ for the comparative value W or L opposite to that of X. Thus, if X = W, $\overline{X}$ = L, and vice versa.

(20) All Grammars of SP2: X,Y,Z $\in$ {W,L}[24]

B	NLW	AxHd	Mat
X	$\overline{X}$		
Y		$\overline{Y}$	
Z			$\overline{Z}$

[24] The layout of this representation suggests that we might also meaningfully call this form of typology 'diagonal'.

This observation immediately gives us the entire property analysis. It consists of three *elementary properties*, those in which a single, named constraint antagonizes another single, named constraint.

(21) Properties of SP2

Name	Property
p.**MAT**	sp.Mat <> m.Bin
p.**HD**	m.AxHd <> m.Bin
p.**LO**	m.NLW <> m.Bin

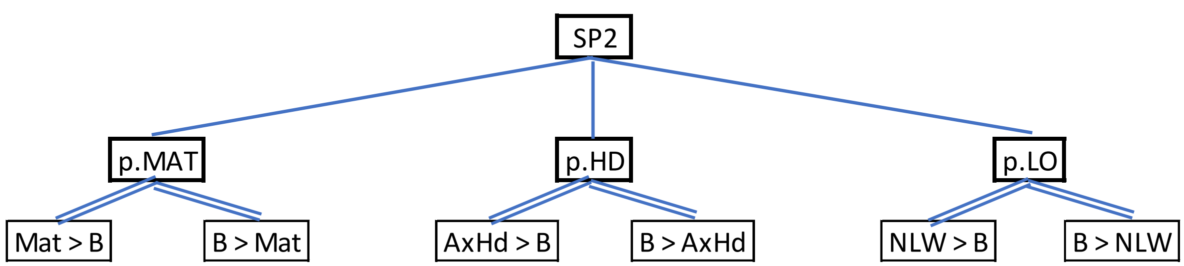
All properties are wide-scope and play out freely against each other. The resulting assignment of values is given in full below. In this table, we write "b" for the right-to-left reading of the value, in which m.Bin dominates, and "a" for its opposite, in which m.Bin is dominated.

(22) Property Analysis of SP2

SP2	**p.MAT**	**p.HD**	**p.LO**
Btop	b	b	b
NL	b	b	a
Ax	b	a	b
NL.Ax	b	a	a
M	a	b	b
M.NL	a	b	a
M.Ax	a	a	b
M.Ax.NL	a	a	a

The analysis takes a simple form in treeoid representation as well. Note the absence of embedding of any properties under a value, indicating lack of scope restrictions.

(23) SP2 Treeoid



With the grammars and the PA in hand, it is possible to make sense of the extensional typology, which we cite accompanied by the analysis of each language's grammar.

(24) Extensional typology of SP2, with PA of the grammars

#	SP2	/ .[u] u. /	/ .[a] a. /	/ .[a] u. /	/ .[u] a. /		p.MAT	p.HD	p.LO
L.1	Btop	.U u.	.A a.	.A o.	.u A.		b	b	b
L.2	NL	.U u.	.A a.	.a [U].	.u A.		b	b	a
L.3	Ax	.U u.	.[A] [A].	.A o.	.u A.		b	a	b
L.4	Ax.NL	.U u.	.[A] [A].	.[A] [U].	.u A.		b	a	a
L.5	M	.[U] u.	.[A] a.	.[A] o.	.[U] a.		a	b	b
L.6	M.NL	.[U] u.	.[A] a.	.[A] [U].	.[U] a.		a	b	a
L.7	M.Ax	.[U] u.	.[A] [A].	.[A] o.	.[U] [A].		a	a	b
L.8	M.Ax.NL	.[U] u.	.[A] [A].	.[A] [U].	.[U] [A].		a	a	a

The Property Analysis can be condensed to C<>B, C ∈ {sp.Mat, m.AxHd, m.NLW}, B = m.Bin. It imposes no direct relations between the various instances of C. This indicates that those constraints dominating B in the grammar of any given language are going to be freely ordered among themselves above B in the legs of that grammar, as shown unmistakably in the full intensional typology laid out in (16) and (19). Similarly, the constraints dominated by B in any grammar show all orders among themselves in the legs of that grammar,. The upshot is that dominating B ensures maximal satisfaction.

The dominators of B are cited in the language names. It is easily confirmed by scanning across the rows that in every case the mentioned constraints are fully *satisfied* in the language. In L.2 NL, for example, there is *no low word*; and in L.3 Ax, every underlyingly accented word /a/ does in fact appear in head position; similarly, the languages L.5–L.8 all contain M in their names and all optimal outputs are all perfectly ‘matched’ to their inputs syntax-to-prosody-wise.

This observation gives an entry-level view of the extensional typology: any subset of the three ‘phonological’ constraints, from none to all, may be enforced to yield a collection of structural patterns in the optima. The next step is to identify how they are enforced via the prosodic parses, which accomplish their visible effects indirectly.

(25) Manifestations of satisfaction

Constraint	IO map	Where
m.NLW	u → [U]	/a/—
sp.Mat	[w] → [W]	.—
m.AxHd	a → A, [A]	—, with further details

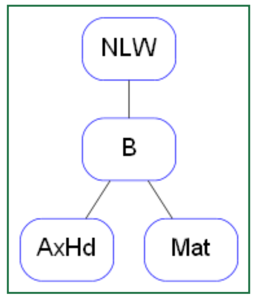
The boolean-like character of the system is evident. Moving across the columns in the PA table from left to right, each vertical value group is successively bifurcated, as in the standard presentation of a truth table for propositional calculus. Concomitantly, the sets of supra-B constraints are exactly the subsets of {sp.Mat, m.AxHd, m.NLW}, yielding the 2^3 grammars.

This arrangement makes the analysis look parametric, with constraints simply turned off or on. But a property value doesn't just name an undominated constraint: it gives a *relation* between one constraint and another. Thus, while the "b" value in the SP2 PA— generically B > C, with B = m.Bin dominating — does indeed extinguish the subordinated constraint C as a factor in selecting among possible optima, the "a" value C > B does more than force the supremacy of C: it establishes subordinated B = m.Bin as the default decider when the dominating antagonist C fails to eliminate all competitors to an optimum.

Consider, for example, L.2 NL. Here is its grammar:

(26) Grammar of g.NL

B	AxHd	NLW	Mat
W	L		
L		W	
W			L



The impact of the constraint m.NLW is felt only in the cset based on input /.[a] u./. When dominant over m.Bin, the constraint m.NLW forbids the appearance of the *low word* o, which occurs only in that one cset. There a structural articulation is forced: to avoid o in the output, the /u/ of /a u/ must be rendered as a prosodic phrase unto itself, [U], which places /u/ in phrase-initial position. No consequences fall on the other csets, which must therefore be adjudicated on different grounds.

But even in this cset, the constraint m.NLW does not choose a single form as the best performer. Two candidate outputs from /.[a] u./ — namely, .a [U]. and .[A][U]. — survive m.NLW in L.2. The first has only one unary constituent and therefore ousts the second on m.Bin.

In the other csets, which are impervious to skepsis by m.NLW, binarity does *all* the work winnowing possible optima. Here the winners are:

.U u. instead of .[U] u.
.A a. instead of .[A] a. or .[A][A].
.u A. instead of .[U] a. or .[U][A].

In each case, the losing alternatives contain strictly more instances of unary [X] than the winner.

The full impact of m.Bin can be seen in the following pair of tables, which are meant to bring out key aspects of how the typology works. In the first table, we show where the B-dominating constraints make a *unique* choice of optimum, given an input set consisting of non-harmonically bounded candidates. This is parameter-like behavior, in which fixing a parameter immediately makes the decision. Green cells contain these forms. Tan cells have further selections to be made. For convenience of reference, the possibly optimal outputs are listed in full in the last row.

(27) Unique Optima chosen by the constraints in language names, from poss. optima

#	SP2	/ .[u] u. /	/ .[a] a. /	/ .[a] u. /	/ .[u] a. /
L.1	Btop	.U u.	.A a.	.A o.	.u A.
L.2	NL				
L.3	Ax		.[A] [A].		
L.4	Ax.NL		.[A] [A].	.[A] [U].	
L.5	M	.[U] u.			
L.6	M.NL	.[U] u.		.[A] [U].	
L.7	M.Ax	.[U] u.	.[A] [A].		.[U] [A].
L.8	M.Ax.NL	.[U] u.	.[A] [A].	.[A] [U].	.[U] [A].
All possible optima		.U u. .[U] u.	.A a. .[A] a. .[A] [A].	.A o. .[A] o. . a [U] .[A] [U].	.u A. .[U] a. .[U] [A].

Removing these selections from view, we now display the optima chosen by m.Bin from among other possible optima that survive filtration by the constraints dominating m.Bin. In each case, a unique form is chosen.

(28) Choices made by m.Bin after filtration by constraints in language names

#	SP2	/ .[u] u. /	/ .[a] a. /	/ .[a] u. /	/ .[u] a. /
L.1	Btop				
L.2	NL	.U u.	.A a.	.a [U].	.u A.
L.3	Ax	.U u.		.A o.	.u A.
L.4	Ax.NL	.U u.			.u A.
L.5	M		.[A] a.	.[A] o.	.[U] a.
L.6	M.NL		.[A] a.		.[U] a.
L.7	M.Ax			.[A] o.	
L.8	M.Ax.NL				
All possible optima		.U u. .[U] u.	.A a. .[A] a. .[A] [A].	.A o. .[A] o. .a [U] .[A] [U].	.u A. .[U] a. .[U] [A].

Recall that the m.Bin penalty is exactly the number of occurrences of [X] in a form. The 'most binary' (least unary) alternatives consistent with prior filtration are chosen. Taking the two tables together, we see that a confrontation with m.Bin takes place in the derivation of *every* language. Notice that this selection makes use of the basic resource of OT, 'minimal violation', in that sometimes the choice is between a penalty of 1 vs. 2, as for example in L.5 M, where of the two matching forms .[A] [A]. and .[A] a., the first is ejected on grounds of excessive unarity even though the second features a unary P constituent.

The role of binarity, as incorporated in the constraint m.Bin, is thus not at all marginal. We see in table (28) that *when dominated* m.Bin makes 15 of the 28 final choices between possible optima in languages L.2-L.8. This behavior, asserting a crucial binarity-sensitive default, distinguishes dominated/undominated status from the off/on modes of a parameter.

This overview leads to a concise formulation: the optima for an SP2 language are the *most binary* members of the set of possible optima that satisfy a certain subset of the constraints {sp.Mat, m.AxHd, m.NLW}. Among other points of interest, we have found that *matching* as incarnate in sp.Mat is not, as intuition might lead us to believe, the central issue that every other constraint must contend with; if anything, it is binarity that fills this role.

There is an immediate temptation to conclude that the *b*-value of a property, of the form B > C, leaves the dominated constraint C without effect on the outcome, and that therefore a constraint ranked below m.Bin is turned off like a spurned parameter. But even a B-dominated constraint C may be involved in a crucial decision — not among the set of possible optima in SP2, but among those candidates which are harmonically bounded. Recall that a harmonically bounded candidate is one that loses to something else no matter what the ranking is.[25] This means that in filtration by any leg, there must be a constraint that deals with it, somewhere.

Consider the following case, from the cset based on /.[u] a./, with zeroes removed to highlight the penalty structure. The output .U a. is simply bounded by .u A., as shown by the highlighted violations.[26] They share a penalty on sp.Mat, and in addition .U a. violates m.AxHd. Clearly, there's no ordering of the constraints that can overcome the m.AxHd deficit. Nevertheless the bounded candidate .U a. is as perfect on both m.Bin and m.NLW as its bounder .u A., and therefore the pair of them can make it through those constraints, separating only whenever m.AxHd is encountered.

(29) All candidates from /.[u] a./

input	output	opt	**m.NLW**	**m.AxHd**	**sp.Mat**	**m.Bin**
/.[u] a./	.u A.				1	
	.U a.			1	1	
	.u [A].				1	1
	.[U] a.			1		1
	.[U] [A].					2

[25] If there is one candidate that is better than the target in all legs, then the bounding is termed *simple*. If there is no single candidate that does the work, but it is nonetheless the case that in whatever leg the target form loses to something else, then bounding is *collective* (Samek-Lodovici & Prince 1999, 2005). All bounding in SP2 is simple, as the reader may confirm though scrutiny of table of (14) and the discussion below it. Depending on the system, collective bounding can be quite pervasive.

[26] The candidate with output .u [A]. is also bounded by .u A., but we focus specifically on how .U a. is handled.

Consider the language L.1 Btop, in which m.Bin (leftmost column) dominates everything else. Since both outputs .u A. and .U a. are perfectly binary, they pass through top-ranked m.Bin, even though no other candidates from /.[u] a./ do. Here m.AxHd stands below m.Bin in all the legs of the grammar, yet it makes its force felt even in the lowliest position, expelling .U a. from contention.

A similar effect obtains in L.2 NL, whose grammar is shown in (26), where the two purely binary candidates from /.[u] a./ pass through m.NLW before meeting m.Bin, after which a similar story unfolds. Far from being muted by m.Bin, the dominated constraint m.AxHd stands ready to actively block .U a. from the light of day. Thus, domination by m.Bin is no guarantee of turn-off and once again parametric-like behavior is not in evidence. Similar remarks may be made about the role of sp.Mat in dealing with bounded forms in languages L.1 to L.4 in which sp.Mat is dominated by m.Bin.[27] Hence, again, *pseudo*-parametric.

With these considerations in mind, the key to understanding the distribution of forms in the typology lies in recognizing the structural configurations that follow inferentially from the definitional demands of the constraints. For example, the constraint m.AxHd, when dominant over m.Bin, forces every underlying word /a/ into head position, where it is written A. But given the input /.[a] a./, getting to surface A requires the 'epenthetic' parse .[A][A] because .[A] A. is not a possibility allowed by SP2.Gen: it would designate the second A as head of the whole phrase, a privilege reserved for P in an asymmetric .P w. structure.

These observations about the derivation of the extensional typology both clarify and complicate the notion of a 'trait' that a property subserves. A trait may be thought of, broadly, as a stable extensional pattern, either in the output or the input-output map, for the appearance or non-appearance of which a certain property value is sufficient (and perhaps also necessary). Traits are deemed linguistically significant by a grammar because of this relationship.

Traits and trait formulations, however, may vary in specificity: for example, the trait "onsets not required" posited by P&S:111*ff.* generalizes over the entire surface inventory of a language and doesn't describe or dictate the parse of individual forms.[28] To cite a stark example: even if lack of onset is allowed, a form like /CVCV/ will necessarily be parsed .CV.CV. and never .CVC.V. in every language of the syllable systems under scrutiny (P&S:107). Similarly, the tight distribution of epenthesis sites allowed by the syllable structure systems (P&S:116-8), an important trait for sure, is arrived at only by a course of reasoning that depends on information about the theory, drawn from *S*.Gen, *S*.Con, and the general definition of optimality and its consequences, that goes well beyond what a single property value can provide.

---

[27] See the discussion below table (14) above for identification of the forms which are bounded due to m.AxHd or to sp.Mat violations. The group failing on sp.Mat includes .u [U]., .a [A]., and .u [A]. . The group failing on m.AxHd includes .a O. in addition to .U a. .

[28] This trait is linked by P&S to the proto-property value f.dep & f.max > m.Ons, or more property-theoretically put, {f.dep, f.max}.sub > m.Ons, as shown in §2.2 below.

In the present case, we have seen that the constraint m.Bin acts on a candidate set in typical OT fashion choosing forms that *most* adhere to its demands (i.e. least depart from them). This allows it to define an outcome which doesn't amount to a specifiable single extensional target, but rather refers to an extensional *scale*, which rates and relates output forms. The tripartite scale emerging from SP2 runs like this, from most to least binary, according to the evaluations of the constraint m.Bin.

(30) Scale of Prosodic Binarity in output

.ww. > .[w]w. / .w[w]. > .[w][w].

Since in this case, embedded P = [w], we may also write it like this:

.ww. > .Pw. , .wP. > .PP.

Any choice that depends on this scale is, of course, relative to the candidates it chooses among. Thus, outputs .A A. and .[A] a. and even bottom-dwelling .[A] [A]. are all possible in the right circumstances. Contrast the absolutist behavior of sp.Mat, which looks for an initial unit phrase and gets one when it dominates its antagonist m.Bin.

Pulling together what we've observed about the extensional-intensional relation in SP2, we offer the following characterization of the traits associated with the property analysis, pulling out reference to the binarity scale shared by all traits.

(31) Values and traits in SP2

Prop	Value	Trait
p.LO	a. m.NLW > m.Bin	Output ⋯[U]. is obtained from /au/
	b. m.Bin > m.NLW	Output ⋯o. obtained from /au/
p.MAT	a. sp.Mat > m.Bin	The match .[W]⋯ required
	b. m.Bin > sp.Mat	Non-match .w⋯ or .W⋯ allowed
p.HD	a. m.AxHd > m.Bin	Head A required for all accented input /⋯ a⋯/
	b. m.Bin > m.AxHd	Nonhead a and head A allowed

(32) Binary Default

In any individual cset, the most binary output form is obtained, according to scale (30), that meets the requirements of the value settings of the grammar as laid out in table (31).

The value settings all follow the same basic pattern: value (a) imposes some necessary requirement and value (b) negates it by declaring that it's *not* necessary, which doesn't amount to declaring that some other particular thing is. This is true even of p.LO.b, which unlike the others sponsors a single determinate outcome constrasting with that of p.LO.a. The value p.LO.b opens up the possibility that final u from /au/ *need not* be bracketed as the P-level phrase [U]. In each case, the most binary item meeting the other requirements abandons the final P as an offense to binarity and is therefore realized as terminal o. Thus the statement of p.LO.b in (31) could be generalized to look like all the other b-value statements, at the cost of perspicuity.

To aid access to the trait analysis, we supply a slightly modified version of table (24). The table contains the extensional typology and the Property Analysis as well as the possible optima associated with each cset. In addition, the language rows are arranged to group together the grammars that have the same number of a-values, and the possible optima are supplied in the last row, arranged top to bottom in order of their binarity.

(33) Extensional typology with Property analysis of grammars and possible optima

#	SP2	/ .[u] u. /	/ .[a] a. /	/ .[a] u. /	/ .[u] a. /		p.MAT	p.HD	p.LO
L.1	Btop	.U u.	.A a.	.A o.	.u A.		b	b	b
L.2	NL	.U u.	.A a.	.a [U].	.u A.		b	b	a
L.3	Ax	.U u.	.[A] [A].	.A o.	.u A.		b	a	b
L.5	M	.[U] u.	.[A] a.	.[A] o.	.[U] a.		a	b	b
L.4	Ax.NL	.U u.	.[A] [A].	.[A] [U].	.u A.		b	a	a
L.6	M.NL	.[U] u.	.[A] a.	.[A] [U].	.[U] a.		a	b	a
L.7	M.Ax	.[U] u.	.[A] [A].	.[A] o.	.[U] [A].		a	a	b
L.8	M.Ax.NL	.[U] u.	.[A] [A].	.[A] [U].	.[U] [A].		a	a	a
Possible optima		.U u. .[U] u.	.A a. .[A] a. .[A] [A]	.A o. .[A] o. .a [U] .[A] [U].	.u A. .[U] a. .[U] [A].				

Observe that the forms in each row do indeed satisfy the correlated a-values.

- Btop has *no* a-values and maximal binarity is the result.
- Languages L.2, 3, 5 show their one a-value trait.
  - L.2 NL avoids the low word with [U]. Other forms identical to those of Btop.
  - L.3 Ax shows only A from /a/.
  - L.5 M shows a match .[W] in every form.
- Languages L.4, 6, 7 meet both a-value traits that their grammars require.
  - L.4 Ax.NL shows A from /a/ everywhere and ⋯[U]. from /au/.
  - L.6 M.NL has all outputs matched as .[W] and ⋯[U]. from /au/.
  - L.7 M.Ax has all outputs matched as .[W] and shows only A from /a/.
- Language L.8 M.Ax.NL has all outputs matched as .[W], shows only A from /a/ and only ⋯[U]. from /au/.

It may be confirmed by inspection that all other aspects of the optimal output follow from choosing the maximally binary option available, according to scale (32).

Thus, SP2 submits to a complete explication of its traits through the Property Analysis, with the set of trait statements (31) taken in the context of the binary default (32).

2.1.4 Analysis by Search: Why Japanese is Ax.NL

A principal empirical aim of MTP, and therefore of SP2, is to provide (Tokyo) Japanese with an analysis for as much of its intonational structure as is admitted into view.[29] Developing an analysis under OT cannot be a matter of forming generalizations and encoding them directly in constraints, a fact of the theory emphasized in Ch. 1. The constraints of a system, as defined, will typically be distant from the patterns that emerge in the resultant typology, both in the entities they name and the demands they place on them. They are also likely to be distant from the basic observable data (‘*facts*’) that linguistic constructs ultimately depend on. Two questions arise:

- Existence. Does the system provide an analysis that correctly renders the facts?
- Ambiguity. Does the system provide more than one such analysis?

The ambiguity question becomes particularly important when arguments for the necessity of assumptions are in play.

More broadly, these questions arise in virtually any theory deploying entities more abstract than classes of data. In the case at hand, the prosodic theory deals in constituency and hierarchy while the facts to be explained in Japanese are (phonologically) tonal and (phonetically) pitch-related. Constituency is not an observable, even in syntax, or anywhere close to being one. Consequently, to reach the observables — or more realistically, some construal of them — we require bridging assumptions. Only when these are in place is it possible to discern the relation of the theory to the observables that it aims to explicate.

Since hierarchical structure is often richer in distinctions than the local facts offered in its support in a given case, the structural rendering of any one language or any one form is often going to contain unrealized elements, at least as far as the available evidence goes. For example, with only the (quasi-observable) information that a trisyllabic form is stressed σ σ′ σ, we cannot know whether it is parsed as .σ [σ′ σ]. or .[σ σ′] σ. — or in some other way, depending on the assumptions of the theory we’re using to analyze it. Similarly, prosody with a given language is often sensitive to only one edge of a foot or a prosodic constituent of higher level, giving the other edge inferential status.[30] Along the same lines, the notion of ‘headedness’ plays a key role in the constraints of MTP/SP2, but as we have noted in setting up SP2, it’s not the case that a head is directly signaled by some palpable effect.

[29] MTP also explicates the similar pattern of Northern Biskaian Basque. The same procedures undertaken for Japanese will find the Basque analysis in the SP2 typology. Since Basque is the same as Japanese in the forms examined here except for allowing the low word, the searcher will not be surprised to discover that Basque is L.3 Ax in the SP2 typology. See Ito & Mester (2020:258, ex. (9)).

[30] Thus in metrical stress theory, evidence for the edge opposite to that hosting the head of a foot is of particular value. See, for example, Prince (1980:552) for a foot-final lengthening effect in trochaic (i.e. head-initial) Estonian, building on phonetic work of Lehiste (1965, 1966) and others. See Leer (1985a, b, c) for foot-initial fortition in iambic (i.e. head-final) Yupik, further examined in Hewitt (1991, 1992, 1994), Hayes (1995), Alber (2006).

A consequence of this impoverishment is that several structural analyses of the same tonological/phonological facts (or interpreted facts) may be available not just in the wide landscape of linguistic thought, but within a given, specified theory. Generically, a theory will predict a *set* of analyses. It is the analyst's job to find them.

Which if any of the grammars of SP2 can be recognized as rendering the relevant facts of Japanese? We can be confident from the analytical work of Ito & Mester that at least one exists, but we want to know about any others, to determine exactly what MTP/SP2 requires of the prosodic structure of Japanese. And if there is only one, we'd like to know why that is the case.

The method we use to answer the question can be called *analysis-by-search*. We gather all the grammars provided by theory, its *typology*, and search among them for those that accord with the motivating facts, given a way of relating the facts to the structures deployed in the grammars.

The key premise linking prosodic structure and (near-) observables in Japanese is this: prosodic phrases at the P level are accompanied by an initial rise LH. [31] We notate the rise as ↑, placed between the syllables carrying the L and the H.[32] This phrasal fact sits on top of the basics of lexical tonology: words may contain an underlyingly *accented* syllable, initiating a fall HL, which like the rise places one tone per syllable. This we notate as ↓, placed after the syllable bearing the H, allowing us to sketch the tonal pattern concisely. Words without lexical accent are plentiful, and acquire their tonology contextually, as tones persist rightward until they encounter another tone.[33]

These effects can be seen in the following examples, modified slightly from MTP.[34] Lexical accent on syllables in exs. (iii) and (iv) is indicated by bolded small caps, and by bolded **σ** in the pattern schemata.

[31] See e.g. Ishihara (2015:572-574) for discussion. Other factors that reflect aspects of phrasing include downstep and its attenuations, boosts, and resets. See Ishihara (2015:582-5).

[32] In this work, the up- and down-arrows are offered without ontological commitment, as signals to the reader. It is entirely possible to build a full theory of tone based on tonal transitions rather than tonal targets; see Clark (1978).

[33] Alternatively, phonetics interpolates values between sparse specifications in a way that broadly accords with this description (Pierrehumbert & Beckman 1988). At any rate, the phonology must be able to access the relevant information if a constraint like Ito & Mester's NOLAPSE, here abbreviated to m.NLW, is to be evaluated.

[34] We thank Junko Ito for help with the mods, though we claim responsibility for any errors.

(34) Realization of unaccented ("u") and accented ("a") words in phrase initial position

	Type	Word	[L H …	Pattern	Gloss
i.	u	/sakana/	[$_P$ <u>sa</u>↑kana	<u>s</u>↑s s	fish
ii.	u	/hiroshima/	[$_P$ <u>hi</u>↑roshima	<u>s</u>↑s s s	place name, surname
iii.	a	/o**KA**yama/	[$_P$ <u>o</u> ↑**KA**↓<u>yama</u>	<u>s</u>↑**σ**↓ <u>s s</u>	place name, surname
iv.	a	/ata**MA**+ga /	[$_P$ <u>a</u> ↑ ta **MA**↓<u>ga</u>	<u>s</u>↑s **σ**↓ <u>s</u>	head (+ nom.)

Every listed word begins with a phrasal rise. Low tone is indicated by underlining, high tone by plain text. We assume a syllable has no more than one tone. After the P-initial rise LH, the H persists through lexically unspecified syllables, as in (i) and (ii). Similarly persistent is the L of accentual HL, visible in example (iii).

For completeness, we mention two further refinements that show up when a word lacks sufficient syllabic territory to accommodate every tone.

i) Rise Overlaps Accent

- If the H of the initial LH is coincident with the H of the accent HL, they are realized as one H. For example, <u>o</u> ↑**KA**↓<u>yama-no</u>, ex. (34) = LH(rise)+HL(acc).
- If the HL accent is word-initial, the P-initial rise does not appear at all, since the L is dropped and the H merges with that of the accent, or simply disappears.

ii) Clitic as Carrier

- If the HL accent is word-final, the L is unrealized except when a postpositional clitic is attached, which carries the L and otherwise behaves tonally as part of the word, as seen in ex. (iv). Thus:

(35) Final Accent

	Lexical	P-initial	Pattern	Gloss
i.	/ata**MA** /	[<u>a</u> ↑ta **MA**↓ L H **H**	<u>s</u> ↑ s **σ**↓	head
ii.	/ataMA+ga/	[<u>a</u> ↑ta **MA**↓ <u>ga</u> L H **H** **L**	<u>s</u> ↑ s **σ**↓ <u>s</u>	head (nom.)

2.1.4.1 A note on the syntax

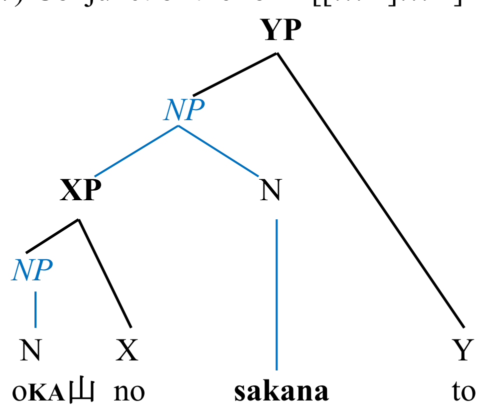
Only syntactic structures of the form [$_{YP}$ [$_{XP}$ X] Y] are considered in SP2. In the Japanese examples targeted in MTP, each of these is the first element of a (truncated) conjunctive structure with later conjuncts left off. They take the following shape:

(36) Terminal structure of cases

o**KA**yama-no sakana -to … 'Okayama's fish and …'
岡 山 -of 魚 -and …

The elements *no* ‘of’ and *to* ‘and’ are enclitic post-positions phonologically integrated with the preceding word. The ur-syntax must be grossly the following:

(37) Conjunct of the form [[…X]…Y]



o**KA**yama *NP*] no **XP]** sakana *NP*] to **YP]**   Remark: only right brackets shown.

At issue here is the presence of the right *NP* brackets splitting the nouns from their postpositions. Following MTP, we abstract away from the conditions that ensure the integrity of the prosodic words N+clitic. The recognized boundaries are those of the phrases labeled **XP** and **YP** in (37), yielding the targeted syntax [YP [XP o**KA**yama-no] sakana-to].

2.1.4.2 The syntax and the prosody

Ito & Mester (2020) propose the following prosodic analyses of left-branching syntactic structure that contains 2 prosodic words. Examples are slightly modified from those of MTP ex. (1), which are cited from Vance (2008:181).

(38) Tokyo Japanese treatment of /.[w] w./

	1. Syntax	2. Prosody	3. Tonology		4. Gloss
i.	.[u] u.	. U u.	hi↑roshima -no	sakana-to	Hiroshima’s fish and …
ii.	.[u] a.	. u A .	hi↑roshima -no	ata**MA**↓go-to	Hiroshima’s head and …
iii.	.[a] u.	.[A] [U].	o ↑**KA**↓yama-no	sa↑kana-to	Okayama’s fish and …
iv.	.[a] a.	.[A] [A].	o ↑**KA**↓yama-no	a↑ta**MA**↓-to	Okayama’s head and …

Since our bridge to phrasing is the presence of the initial rise, we summarize the relevant tonal patterns here, placing the rise mark *before the word* that bears it in natural fluent speech. The facts are due to Kubozono (1988, 1989).[35]

(39) Initial Rise in the 2-word forms

	Lexical	Rises
i.	/u u/	↑u u
ii.	/u a/	↑u a
iii.	/a u/	↑a ↑u
iv.	/a a/	↑a ↑a

The resolving power of the initial rise, and its limitations, may be seen in the example (i) /u u/. A parse .[U] [U]. can be definitively rejected, because it engenders a (nonexistent) rise on the 2nd word. However, the purely binaristic but unmatching parse .U u. and the less-binary but matching parse .[U] u. are both viable as interpretations. The rise occurs at the beginning of phrases, and nothing is known to mark their end. Further, rises do not pile up when several P-phrase edges coincide, as at the beginning of a left-branching structure, and the one rise that is present can only identify the first word ↑u as P-initial — in however many nested P- phrases begin there.

The first step in the analyis-by-search procedure is therefore to collect all possibly optimal parses that successfully yield the tonal data. To reduce clutter, we do not explicitly signal the syntactic parse .[w] w. shared by all inputs.

(40) Rise and Parse

Tonology	Input	Rises	Parses
No rise on 2nd word	/u u/	↑u u	.U u. .[U] u.
	/u a/	↑u a	.u A. .[U] a.
Rise on 2nd word	/a u/	↑a ↑u	. a [U]. .[A][U].
	/a a/	↑a ↑a	.[A][A].

Multiplicity of analysis occurs because only the initial edge of P is detected tonologically; nothing is known to mark the final edge of P in Tokyo Japanese. This engenders no ambiguity in the treatment of the *second word*. If it lacks a rise, it cannot initiate its own unshared P. If it has a rise, it must begin a P, which encloses it.

[35] Ito & Mester (2020:254) note that "[i]t is always possible, in careful pronunciation, to parse each word as a separate φ, with its own initial rise, but this is not the usual pattern…. The data are subject to considerable variation. We focus here exclusively on the majority patterns."

However, the first word is P-initial whether or not it lies within an *embedded* P-phrase, as in .U u. and .[U] u. from /u u/. The same effect is seen in realization of /u a/and /a u/. The entire two-word phrase always begins with a rise, allowing the first word either to be or not to be the resident of its own phrase, possible optima permitting.

Consequently, freely choosing one rise-consistent output from each cset, there are 8 = $2 \times 2 \times 2 \times 1$ full collocations of possible optima across the 4 csets that are consistent with the facts of Japanese.

Nevertheless, the SP2 typology turns out to allow just one of these factually admissible options. To obtain it, we register the extensional typology of SP2 against the optima that are consistent with the rise patterns (39). The colored output cells in the following table contain all structures that predict the observed rises. Parses *inconsistent* with the rise data are greyed out. We seek an entire row that contains only rise-consistent parses.

(41) Searching for Tokyo Japanese

TJ Rise patterns:		↑u u	↑a↑a	↑a↑u	↑u a
Rise-Consistent Optima:		.U u. .[U] U.	.[A][A].	. a [U]. .[A] [U].	.u A. .[U] a.
Lang#	Name	**/.[u] u./**	**/.[a] a./**	**/.[a] u./**	**/.[u] a./**
L.1	Btop	.U u.	.A a.	.A o.	.u A.
L.2	NL	.U u.	.A a.	.a [U].	.u A.
L.3	Ax	.U u.	.[A] [A].	.A o.	.u A.
L.4	**Ax.NL**	**. U u.**	**.[A] [A].**	**.[A] [U].**	**.u A.**
L.5	M	.[U] u.	.[A] a.	.[A] o.	.[U] a.
L.6	M.NL	.[U] u.	.[A] a.	.[A] [U].	.[U] a.
L.7	M.Ax	.[U] u.	.[A] [A].	.[A] o.	.[U] [A].
L.8	M.Ax.NL	.[U] u.	[A] [A].	.[A] [U].	.[U] [A].

Only in L.4 Ax.NL do all the structures yield, under our assumptions, the rise facts of Tokyo Japanese. The table also shows how close the others come, identifying the data commitments that support the claim — crucially, for example, that /a a/ rises twice as ↑a↑a, *not* just once as ↑a a — thereby directing our attention to their importance. It also illustrates the role that choice of constraints plays in dictating the limits of co-occurrence across csets: as noted, the rise data taken on a case-by-case basis limit the structural analysis of Tokyo Japanese to 8 possibilities; the MTP constraints under OT eliminate all but one. Different or additional constraints could easily allow for several other viable analyses.

The table also holds a result of some subtlety. A minimal Universal Support consists of csets {#1, #2, #3} or of csets {#2, #3, #4}, numbering from left to right in the table. Suppose we choose to work from csets #1-3. Observe that over those, Japanese is not unique. The Tokyo Japanese rise pattern is accurately predicted in *both* L.4 Ax.NL and L.8 M.Ax.NL. However, if we look further in those languages, we will find that distinct rise patterns emerge elsewhere, outside the chosen support. In particular, the 4th cset column distinguishes L.4 from L.8, unambiguously identifying L.4 as Japanese.

On top of that, the input /u u/ makes precisely no contribution to the project of distinguishing Japanese data-wise from any other language, even though it is most definitely needed in the Universal Support {#1, #2, #3}.

A Universal Support defines the *grammars*, from which the languages are projected, but there is no guarantee that it displays in explicit form all relevant information about the entire range of candidates outside the Support — how they are parsed and, critically, how they are interpreted as observable data. In particular, a Support, even if Universal and therefore typology-dispositive, may not contain all the forms needed to determine how *languages* as structures correlate with *languages* as they are observed.

2.1.5 Summary

In §2.1, we have probed a typology of syntax-prosody relations with several goals in mind. Chief among them has been to uncover and illuminate aspects of typological structure as they emerge from the commitments defining a particular OT system. The accompanying linguistic goal has been to take steps in the direction of understanding the workings of Match Theory in the context of other relevant constraints, and specifically to move toward situating the analytical insights and strategies of Ito & Mester (2020) in the typological landscape they imply.

In accord with an incremental methodology of theory development, we have examined a system with clear empirical interest while radically restricting focus to a corner of its domain. Under this regime, if rationality and good fortune align, analysis can proceed with depth and certainty, yielding results that can be pursued with justified confidence even when they are not entirely expected on a priori or intuitive grounds.

In the present instance, we tactically restrict the syntax-prosody system of MTP to its simplest nontrivial case involving all and only two-word inputs, with no other twists or limitations beyond those needed to encapsulate the various sources of influence embodied in its constraints. The resulting system SP2 gives rise to a typology built from 'elementary properties' only: those that counterpose one single named constraint against another. Further, all properties turn out to be of the same form: $C_i <> B$, in which a single constraint interacts with the same pivotal antagonist, B (which is m.Bin here). There are no properties setting the C_i against each other and no scope restrictions, deriving therefore 2^n grammars for n constraints C_i, $1 \leq i \leq n$. Thus, the Property Analysis of SP2 generates a set of $2^3 = 8$ grammars, because every possible subset of the set of the 3 non-B constraints, namely {sp.Mat, m.AxHd, m.NLW}, including the empty set, defines a grammar, by virtue of dominating m.Bin, which in turn dominates the complement set of the dominators, with no further ranking restrictions. This immediately recalls a kind of parametric analysis in which the demands of each constraint dominating B would be either met or disregarded, but even a slightly closer look shows further structure that is inescapably characteristic of OT.

Most striking, as we found in reviewing the patterns of filtration, is that the requirements of m.Bin, incarnate extensionally as a hierarchy of structural binarity, are felt pervasively, even when it is dominated. Thus, of the 28 competitions among the possible optima in languages from grammars where m.Bin does not stand at the top of any leg, some 15 are decided by subordinated m.Bin rather than by the constraints that dominate it. Further, in the language Btop, undominated m.Bin makes all choices among possible optima.

In addition, though perhaps less obviously, because simple harmonic bounding is determined by constraints without reference to ranking, even constraints dominated by m.Bin can function to make crucial decisions ejecting harmonically bounded candidates in the course of filtration.

The constraints of SP2 resemble parameters in that when they dominate m.Bin, their demands are satisfied in every optimal form; but they are unlike parameters in that this state of satisfaction does not in itself fully decide the output of a grammar. They function in a system with a default that decides everything among possible optima that they don't. And even when dominated by m.Bin, their force is persistently felt, specifically in determining the fate of harmonically bounded candidates. Thus, we call this kind of typology *pseudo-parametric*, because it shows some key parametric features amid others that arise within the OT context ― from the very same mechanism that delivers the parametric-like behavior.

The intonational (quasi-)observables are construed in MTP as arising inferentially from a constituency that is not itself directly observable. Of particular interest are the factors that give the MTP analyses their explanatory depth, which are quite diverse and must be integrated representationally to obtain a coherent account. These include output tonology, phonological structure at the lexical level, as well as input syntactic structure and output prosodic structure with their level and headedness requirements, partly shared.

The direct approach to this multiplicity of influences would articulate each one to a fair level of detail, and then attempt to operate within the resulting plethora of interactions. Our approach, by contrast, which accords closely with that taken in MTP, has been to insist on targeting the central syntax-prosody interaction and encapsulating the components of the analysis that bear on it, avoiding envelopment in their intricacies. This has allowed the key features of the syntax-prosody system — and of its interactions with the results of other subsystems — to emerge with some clarity.

It's worth noting that certain aspects of simplification are likely to be more than heuristic and temporary: for example, representing both syntax and prosodic structure in an identical level system brings out a pervasive feature of analysis in the area, rather than merely packaging up subsystems for clean use. Analogously in stress typology, treating the syllable as an opaque unit, as we have done and will do, is an entirely accurate rendition of the role of the syllable's internal structure — none — in the subtheory of 'quantity insensitive' stress, and therefore loses nothing, and even gains by explicitly avoiding overcommitment to irrelevant details. (For this reason, similar moves have been made since the inception of modern hierarchical prosodic theory.) A significant property of this simplifying approach, whether the measures taken are heuristic and short-term or well-motivated and theory-improving, is that a degree of exactitude can be maintained sufficient to support use of the theory *as defined*. In working with a system *S*, we cannot sacrifice the statement of *S*.Gen and *S*.Con without compromising the very basis of the theoretical enterprise.

With the typology of SP2 in hand, the project of locating Japanese within it becomes feasible, but discloses another critical aspect of sound linguistic analysis. Grammars are framed in terms of abstract categories and relations; but the observable facts they are meant to explain are typically of a quite different character. Specific hypotheses are therefore required that tie the entities of grammar, for example those that emerge in an OT system *S* from *S*.Gen and *S*.Con, with (interpreted) observables of various kinds. In the present case, the grammar presents us with prosodically bracketed strings, but prosodic phrases and levels are not registered by instrument or by ear. The bridging correlation rests on the construal of a certain tonal motif — the rise — as marking initial position in a prosodic constituent of level P, often written as φ in the literature. Any bracketing of the word-string that imposes P-initial positions consistent with the rise pattern will therefore count as 'Tokyo Japanese'. Since no distinction is posited between environments [P— and [P[P —, and since nothing is posited here as the phonetic correlate of phrase-*final* position in that language, a certain amount of structural ambiguity results, even in the simple cases considered in SP2.

The place (or places) of Japanese in the full typology, if any, must therefore be ascertined by what we have called *analysis-by-search*. We are looking for those languages with an output bracketing structure that derives the Tokyo rise pattern. A survey of the possibilities shows that some 8 different collocations of possible optima, freely pulling one rise-consistent form from each cset, give that pattern. The grammars of the typology, however, impose strong restrictions on choice not just within but across csets by requiring that successful candidates meet shared requirements. Filtering the typology with respect to rise-consistency, we find that only one of its grammars selects suitable optima across the board. Ito & Mester's analysis is therefore confirmed as finding a grammar, as expected given the validity of their reasoning, and it is in addition found to be *unique*, given the assumptions of MTP/SP2.

These considerations show that the typological method is essential if you want to establish both the validity and the uniqueness of a proposed analysis. This outcome is surely not parochial to OT: using any theory requires obtaining at some point a grasp of its consequences. As the assumptions of a theory become more abstract, and the consequences less accessible, it becomes all the more necessary to develop ways to analyze the theory side-by-side with ways to analyze the data.

In the particular case at hand, yet another subtlety is disclosed. To ascertain the grammars of a typology, a sufficiency of inputs is required: a *Universal Support*. If the Support examined is too thin, grammatical distinctions made by the constraints of *S*.Con among the candidates of *S*.Gen will not be recognized.[36] At least one of the grammars projected from an insufficient support will be 'too big', in that it encompasses two or more grammars of the actual typology of the system *S* as defined. The reason will be that the actual grammars agree on the treatment of certain inputs, and unless you test them against others, this narrow agreement can be mistaken for agreement everywhere.

When we undertake analysis-by-search, a similar misstep can corrupt the results. If we don't examine a sufficiency of csets, two distinct languages-of-the-typology can be realized identically over the csets we do examine, suggesting the false conclusion that they are realized identically everywhere. This type of slip was narrowly avoided when the SP2 typology was analyzed-by-search for Tokyo Japanese. As was noticed, over the assembly of csets #1, #2, and #3, Japanese appeared to manifest two structurally distinct languages, namely L.4 Ax.NL and L.8 M.Ax.NL, which differ in whether input-output matching is required. Only when cset #4 was included did these two diverge in a way that confirmed one as Japanese and excluded the other.

But the collection {#1, #2, #3} is a Universal Support for SP2, fully determining the grammars of the typology. The match/nonmatch distinction turns out to be made in this Universal Support via the cset from /[u] u/, with optimal outputs [u u] and [[u] u] in which both possible optima are rise-consistent with the observed pattern ↑u u. This support therefore doesn't show whether the facts of Tokyo Japanese require matching or not. It turns out that even though a valid Universal Support will determine every detail of the grammars of a typology, its csets may not overtly display all the crucial consequences of those grammars — the signs and symptoms that figure in the realizational principles linking linguistic structures to observable events in the world.

The larger scale conclusion is that a validity-driven methodology can deliver useful insights even in circumstances of tight focus on a narrow range of formal and empirical phenomena.

[36] See Alber, DelBusso, and Prince (2016) for analysis of the Universal Support situation in the system nGX, a stress typology discussed in Ch. 4 below.

2.1.6 Postlude. Pseudo-Parametric Typologies in General

The species of typology exemplified by SP2 is called 'pseudo-parametric' because it has a Property Analysis that resembles a set of conventional parameters, but differs in crucial respects, essentially because strict domination does not necessarily turn constraints off. The PA contains n properties of the form $P_i = [C_i <> B]$, for S.Con = $\{C_1, \ldots, C_n, B\}$, which freely combine in the wide-scope fashion to derive 2^n grammars, just as n unrestricted parameters do. Furthermore, as we have seen in the case of SP2, the property P_i is such that the value $C_i > B$ requires (of optima) the minimal penalty on C_i, typically 0. The opposite value $B > C_i$ reduces the activity of C_i. A dominated C_i, as we have seen in the case of SP2, has no effect at all on the choice of optima from among the set of possible optima, though it may play a crucial role in dooming harmonically bounded forms. But this is not the end of the story. The constraint B participates in every property and provides a default with a major extensional effect: B decides any choices among possibly optimal alternatives that are left open by B's dominators, and thus provides what may be be termed a 'default' criterion of choice. The prefix 'pseudo' indicates that the parametric off/on story is not a perfect fit with OT.

A system Ψ has a pseudo-parametric PA (or simply put, *is* pseudo-parametric) if every grammar of its typology takes the form of the following Hasse-like diagram, which displays disjoint sets $\mathcal{C}_{\text{Top}}, \mathcal{C}_{\text{Bot}} \subseteq \Psi.\text{Con} - \{B\}$, where either may be empty. The interpretation of the schematism is that every constraint of $\mathcal{C}_{\text{Top}}$ dominates B, while B dominates every constraint of $\mathcal{C}_{\text{Bot}}$, while the constraints within $\mathcal{C}_{\text{Top}}$, as well as those of $\mathcal{C}_{\text{Bot}}$, freely assume any domination relation among themselves in the legs of the grammar thus defined, i.e. are not 'crucially ordered' in the vernacular of the field.

(42) Grammar schema in a pseudo-parametric typology

$$\begin{array}{c} \mathcal{C}_{\text{Top}} \\ | \\ \text{B} \\ | \\ \mathcal{C}_{\text{Bot}} \end{array}$$

Observe that schema (42) does indeed define a grammar. Every ERC set defines a grammar and any set of total orders on S.Con that extends a partial order can be delimited by an ERC set, like any other partial order.

A pseudo-parametric typology contains as grammars every choice of $\mathcal{C}_{\text{Top}}$ and $\mathcal{C}_{\text{Bot}}$ which meets the following obvious restrictions

$$\mathcal{C}_{\text{Top}} \cap \mathcal{C}_{\text{Bot}} = \varnothing$$
$$\mathcal{C}_{\text{Top}} \cup \mathcal{C}_{\text{Bot}} = \Psi.\text{Con} - \{B\} \ .$$

(43) **Pseudo-parametric typology**. For an OT system Ψ, let Ψ.Con be a set of constraints, and let $T_\Psi = \{G_1, \ldots, G_m\}$ be a typology of Ψ meeting the restriction that every grammar $G_k \in T_\Psi$ is of the form (42) and every grammar G_j on Ψ.Con that has the form (42) belongs to T_Ψ. Then T_Ψ is said to be *pseudo-parametric*.

For $|\Psi.\text{Con}| = n + 1$, the set T_Ψ contains 2^n grammars in total. When $|\mathcal{C}_{\text{Top}}| = m$, $0 \leq m \leq n$, there are (n *choose* m) distinct choices for $\mathcal{C}_{\text{Top}}$, and each such choice produces a distinct grammar. The total number of grammars is therefore 2^n, by the familiar identity:

$$\sum_{m=0}^{n} \binom{n}{m} = 2^n$$

We have, then, a collection T_Ψ of 2^n grammars, for $|\Psi.\text{Con}| = n + 1$. All of the grammars are pairwise disjoint, since the legs of each grammar are uniquely identified by the constraints $\mathcal{C}_{\text{Top}}$.

As portrayed in (26), the grammars may equivalently be schematized as a collection of ERC sets, writing V_k, $\bar{V}_k$ for comparative values {W, L},where if V_k = W, then $\bar{V}_k$ = L and vice versa.[37]

(44) All grammars of Ψ_n schematized, with $V_k, \bar{V}_k \in \{W, L\}$, $1 \leq k \leq n$

B	C_1	C_2	⋯	C_n
V_1	$\bar{V}_1$			
V_2		$\bar{V}_2$		
…	…	…	…	…
$\bar{V}_n$				$\bar{V}_n$

These tableaux faithfully represent the Hasse diagrams of SP2 (42) for $1 \leq k \leq 3$. Since there are 2 free choices for each value variable (namely W, L), there are clearly 2^n such tableaux for the $n + 1$ constraints. For this reason, pseudo-parametric typologies may also be usefully named 'diagonal'.

How do we know that such a collection of grammars constitutes a *typology*? I.e., how do we know that the object T_Ψ of definition (43) is a *typology* rather than a mere set of grammars?

The question is not idle. Merchant & Prince (2021) show that a set of disjoint grammars may fail to be a typology even if their union contains all the linears orders on *S*.Con, for some system *S*. In the present case, we show that the full set of grammars is indeed a typology by constructing a Unitary Violation Tableau (UVT) for it, in the process gaining some insight into how a pseudo-parametric typology is organized.

[37] If we think of each ERC as defining a directed edge in a graph, where W is the departing end and L the arriving end, and where each constraint is a vertex, then (44) is the *incidence matrix* of the graph, identifying which vertices are incident upon which edges. Interpreted this way, an ERC set is the incidence matrix of a hypergraph. Incidence matrices are typically given as the transpose of the matrices shown here. See Incidence Matrix, Wikipedia.

A UVT for a typology T is a Violation Tableau in which each row, chosen as optimal, delivers a grammar of T and in which every grammar of T has its unique row (Prince 2017 shows that every typology has a UVT). From the basic definitions of OT, we have it that every VT of any character delivers a formal typology with its (non-harmonically bounded) rows each comprising a (one-candidate) 'language' of the typology. Thus, we may be sure that exhibiting a UVT for a set of grammars proves that set to be a typology.

Conversely, every typology has a UVT, and indeed many, one of which may be obtained from the Minkowski sum of the csets in any Universal Support (Prince 2017).[38] We may proceed from any collection of csets to a single UVT with rows that generate exactly the grammars of that collection.

Before confronting the general case, it is instructive to examine the generic four constraint pseudo-parametic typology Ψ_3 on *S*.Con = {X, Y, Z, B}, isomorphic to SP2, which has a UVT that looks like this:

(45) UVT schematized from the known pseudo-parametric typology SP2

Ψ_3	X	Y	Z	B
Btop	1	1	1	0
L.X	0	1	1	1
L.Y	1	0	1	1
L.Z	1	1	0	1
L.XY	0	0	1	2
L.XZ	0	1	0	2
L.YZ	1	0	0	2
L.XYZ	0	0	0	3

This UVT was derived from the Minkowski sum of the 4 csets in SP2 by omitting the harmonically bounded rows and then reducing the entries to the minimal values allowed by the SP2 MOAT (Merchant & Prince 2021). We may therefore be entirely confident that it generates a pseudo-parametric typology isomorphic to that of SP2, a fact that is also easily confirmed by direct calculation.

Observe that the X-Y-Z constraint columns have a distinctly boolean appearance. If we identify 0 with T(rue) and 1 with F(alse), this subtableau mirrors a truth table for prop letters X, Y, Z in which they assume every truth-value combination.

[38] Given sets A = $\{a_i\}$ and B = $\{b_j\}$, consisting of things that can be added to each other, the Minkowski sum $A \oplus B$ is defined as $\{a_i + b_j : a_i \in A \text{ and } b_j \in B\}$, the sum of each member of A with each member of B.

In the OT context, we cannot however obtain a parametric effect from this boolean subtableau alone. If we disable the constraint B, the result is massive harmonic bounding, as can been in this truncated version of the tableau (45).

(46) XYZ subVT without B

XYZ	X	Y	Z
Btop	1	1	1
L.X	0	1	1
L.Y	1	0	1
L.Z	1	1	0
L.XY	0	0	1
L.XZ	0	1	0
L.YZ	1	0	0
L.XYZ	0	0	0

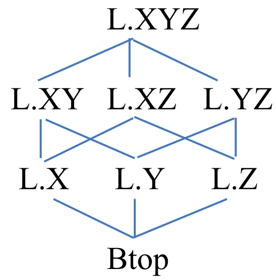
Without B, the language L.XYZ (last row) has 0 in every column. It is therefore the sole possible optimum, bounding all the other rows. Thus (46) is not a VT for anything but the trivial typology {L.XYZ}. Further patterns of harmonic bounding occur among the suboptima, which must therefore be disrupted to obtain a VT that generates the entire set of 2^3 languages.

The general pattern of bounding can be usefully correlated with the naming convention for the languages. The general rule is that any language with X in its name has 0 in the X column; similarly for Y and Z. Columns headed by a letter from {X, Y, Z} that does *not* appear in the name have 1's for that language.

A language L thus harmonically bounds any other language L′ with a shorter name whose name lists a proper subset of the letters in the name of L. For example, L.X is bounded by L.XY. The bounded L′ will have a proper subset of L's zeroes and therefore, crucially, a proper *superset* of its 1's. Thus, L.XY (0, 0, 1), with 1 in Z, bounds both L.X (0, 1, 1) and L.Y (1,0,1), which each share the 1 in Z while containing another 1 as well.

This effect is shown in the following diagram. The 'rank' of a grammar is the number of 0's in its row in tableau (46). The notation {…} indicates the multiset of violation values in each rank.

(47) Inclusion diagram of 0’s on Tableau (46)



Rank 3	{0, 0, 0}
Rank 2	{0, 0, 1}
Rank 1	{0, 1, 1}
Rank 0	⟨1, 1, 1}

A given language row in the truncated UVT (46) will bound all those that are connected to it by a downward path. The layers of the diagram, termed ‘ranks’, are numbered.

From the inclusion diagram (47) it is also clear that within a rank, there is no harmonic bounding. To show this directly, recall that in the case of simple harmonic bounding, the sum of the bounder’s violations will be strictly less than the sum of the violations of any form it bounds. This follows because, in simple bounding, every constraint of the bounder has the same or fewer violations than a form it bounds and in at least one constraint, strictly fewer. Since each member of a rank has exactly the same number of violations, no member can simply bound any other member of that rank. To close the argument, note that no *collective* bounding (Samek-Lodovici & Prince 1999) can take place, since that requires non-boolean violations.

Therefore, bounding arises only between ranks. Bounding can be eliminated, then, by adjoining a new constraint B to the constraint set, designed to ensure that a member of a lower rank, such as L.X, is favored by B over all members of higher ranks. This goal can be achieved by having B assign to each language its *rank number*, as given in diagram (47), which is exactly the total number of 0’s in its X-Y-Z values. The full UVT (45) has exactly this character.

We know without calculation that this method works in the particular case of SP2 because of the way the UVT was derived. But it can be shown without reference to multiple csets or Minkowski summation that the same method of construction works in general to define UVTs for the class of pseudo-parametric typologies. With this UVT in hand, we can then establish the desired result: that a collection of grammars of the form (42) is indeed a typology.

We begin by defining the relevant VT $\mathbb{V}_n$ as a matrix with integer entries. Let it have $n + 1$ columns and 2^n rows, where the entries of the first n columns constitute every possible n-length sequence over {0, 1}. Each entry of the last column records the total number of 0’s in the first n cells of its row. This generalizes the UVT (45) to the case of $n + 1$ constraints.

We name the rows and columns as follows. Let $\mathbb{X} = \{X_1, \ldots, X_n\}$, and let $\mathbb{X} \cup \{B\}$ be the set of labels for columns c_j, $1 \leq j \leq n + 1$, which we will call ‘constraints’. Assign X_i as a label to the i^{th} column, $i \leq n$, and B to the last. We label each row r_k, $1 \leq k \leq 2^n$, with the set of constraints that assign 0 to it. Call this set $Z(r_k)$. Complementarily, let $\overline{Z}(r_k)$ denote the set of constraints assigning 1’s to r_k.We refer to a row as a ‘language’. Define the *rank* $\rho(r_k)$ of a language r_k to be the number of 0's assigned to it by the constraints of $\mathbb{X}$, namely $|Z(r_k)|$. In this terminology, the value assigned by the constraint B is the *rank* of the language. These definitions may be summarized concisely as follows. We write $C(r_k)$ for the value the 'constraint' function C assigns to 'language' row r_k, i.e. the C^{th} component of r_k.

(48) Items of interest

$\mathbb{X} = \{X_1, \ldots, X_n\}$
$Z(r_k) = \{X_i \in \mathbb{X} : X_i(r_k) = 0\}$
$\overline{Z}(r_k) = \mathbb{X} - Z(r_k) = \{X_i \in \mathbb{X} : X_i(r_k) = 1\}$
$\rho(r_k) = |Z(r_k)|$
$B(r_k) = \rho(r_k)$

We now show that $\mathbb{V}_n$ is a UVT for the collection of grammars Ψ_n, as defined in ex. (43), entailing that Ψ_n is a typology. Consider the grammar g_k that renders the row r_k optimal. We claim that every leg λ_j that consists of the constraints of $Z(r_k)$, in any order, followed by B, followed by the constraints of $\overline{Z}(r_k)$ in any order, must belong to g_k. Then we show that no other constraints can belong to g_k. We write $\lambda(\mathbb{V}_n)$ for the result of filtering $\mathbb{V}_n$ in the usual OT fashion by λ, a linear order on $\mathbb{X}$.

(49) **Theorem**. Ψ_n is a typology.

Proof. By definition, $\mathbb{V}_n$ has $n + 1$ columns and 2^n rows. We examine a grammar g_k derived from row r_k of $\mathbb{V}_n$ for some arbitrary k, $1 \leq k \leq 2^n$.

Let ω_1 be an arbitrary total order on the constraints of $Z(r_k)$ and let ω_2 an arbitrary total order on $\overline{Z}(r_k)$. Let λ be a total order on $\mathbb{X} \cup \{B\}$ which has the form

(*) $\quad \lambda = [\omega_1 > B > \omega_2]$

We first show by a filtration argument that $\lambda \in g_k$ by showing that $\lambda(\mathbb{V}_n) = r_k$.

Consider first the filtration of $\mathbb{V}_n$ by the initial subsequence ω_1, whose result we denote $\omega_1(\mathbb{V}_n)$. It is immediate that $r_k \in \omega_1(\mathbb{V}_n)$. This follows because ω_1 consists of the constraints of $Z(r_k)$, all of which assign 0 to r_k. Therefore, none can eject r_k as having a nonminimal value. It follows that every other row that belongs to $\omega_1(\mathbb{V}_n)$ must also have 0's in every constraint of ω_1, which orders the constraints of $Z(r_k)$, Thus, if some $r_m \in \omega_1(\mathbb{V}_n)$, then $Z(r_k) \subseteq Z(r_m)$.

From this it follows immediately that the rank of every member of $\omega_1(\mathbb{V}_n)$ is greater than or equal to the rank of r_k. Concisely put, we have $\rho_m = |Z(r_m)| \geq |Z(r_k)| = \rho_k$ for all $r_m \in \omega_1(\mathbb{V}_n)$. Note, however, that no other row of rank ρ_k besides r_k can belong to $\omega_1(\mathbb{V}_n)$. Assume, for purposes of contradiction, that, for some $r_m \in \omega_1(\mathbb{V}_n)$, we have $\rho_m = \rho_k$ but $r_m \neq r_k$. In that case, since $Z(r_k) \subseteq Z(r_m)$ and $|Z(r_k)| = |Z(r_m)|$, we must have $Z(r_k) = Z(r_m)$, since the only subset of a finite set that is equinumerous with the set itself *is* the set itself. But then $\overline{Z}(r_m) = \overline{Z}(r_k)$ and $r_m = r_k$, contradicting the assumption that r_m and r_k are distinct. Therefore, if $r_m \neq r_k$ is such that $r_m \in \omega_1(\mathbb{V}_n)$, it must be that $\rho_m > \rho_k$.

This conclusion allows us to assemble a concrete picture of $\omega_1(\mathbb{V}_n)$. It consists of r_k along with any r_m of strictly higher rank than r_k which is such that $Z(r_k) \subsetneq Z(r_m)$.

It follows immediately from the definition of B that all such r_m are going to be ejected by B in favor of r_k when B is reached in filtration by the λ-initial sequence $[\omega_1 > B]$. The value assigned by B to a row is the rank of that row; thus, $B(r_m) = \rho_m > \rho_k = B(r_k)$. The row r_k has the unique minimal value on B among the $\omega_1(\mathbb{V}_n)$, dooming all the other members of $\omega_1(\mathbb{V}_n)$. Thus, $[\omega 1 > B](\mathbb{V}_n) = r_k$.

Therefore, as claimed, $\lambda(\mathbb{V}_n) = r_k$. This establishes that $\lambda \in g_k$, the grammar associated with r_k, for every λ of the form (*) $[\omega_1 > B > \omega_2]$.

Thus every λ of the form (*) belongs to g_k, for any value of k, $0 \leq k \leq 2^n$. It remains to show that no other λ, of whatever form, belongs to g_k.

We now show that no other total order on $\mathbb{X} \cup \{B\}$ can belong to g_k, using a counting argument. If r_k is of rank p, then ω_1 contains $|Z(r_k)| = p$ constraints and ω_2 contains $|\overline{Z}(r_k)| = n - p$ constraints. A grammar is the set of all legs that deliver the same optima. Here there is one optimum r_k and we seek $|g_k|$, the number of legs that deliver it. The number of legs $|g_k|$ in g_k that are of the form (*) is

$$|g_k| = |\omega_1|! \times |\omega_2|! = p! \times (n - p)!$$

Now, the number of distinct grammars of rank p is given by the number of distinct choices of p zeroes in the n non-B constraints of $\mathbb{V}_n$, when all other choices are of 1.

$$\binom{n}{p} = \frac{n!}{p!\,(n-p)!}$$

Therefore the total number of legs of the form (*) in all the grammars of rank p is

$$\binom{n}{p} \times p! \times (n-p)! = n!$$

The number of ranks is $n + 1$. Therefore, the total number of legs of the form (*) in all ranks is

$$(n+1) \times n! = (n + 1)!$$

But this is the number of legs in the set of linear orders on $\mathbb{X} \cup \{B\}$ because $|\mathbb{X} \cup \{B\}| = n + 1$.

Therefore, once the legs of the form (*) are assigned to each g_k, there are no other legs to be accounted for. Thus, each g_k consists entirely of legs of the form (*).

This shows that the typology of $\mathbb{V}_n$ is exactly Ψ_n. Since the set of grammars Ψ_n has a UVT, namely $\mathbb{V}_n$, it follows that Ψ_n is a typology. □

This method of proof reveals the interesting fact that every rank of a pseudo-parametric typology Ψ_n contains exactly $n!$ legs. Each rank R_p of level p splits up into (n choose p) distinct grammars, each containing p constraints dominating B, which dominates the $n - p$ constraints in the remainder of $\mathbb{X}$. Thus, a rank R_p contains all those legs with B placed in position p in the domination order, counting from left to right, starting the count with 0.

Since $|R_p| = n!$ for all p, $0 \leq p \leq n$, a rank R_p in the permutohedron[39] of Ψ_n can be associated geometrically with the permutohedron with $n!$ vertices, but not in a way that preserves their adjacency, because rank R_p with more than one grammar in it is not a connected region. Indeed, excluding as trivial the extreme cases where rank 0 and rank n contain just one grammar each, no two grammars of rank p are adjacent, $1 \leq p \leq n - 1$. Recall that two legs are adjacent if they are identical except for a single adjacent transposition in their orders, and two *grammars* are adjacent if a leg from one is adjacent to a leg from the other (Merchant & Prince, 2021:31).

[39] On this notion, see Riggle (2010), Prince (2013), Merchant & Prince (2021).

Grammars of the same rank are non-adjacent on the permutohedron hosting Ψ_n, which has $(n + 1)!$ vertices. To get from a grammar containing legs $\omega_1 B \omega_2$ to another containing legs $\alpha_1 B \alpha_2$, with $|\omega_1| = |\alpha_1|$, where ω_1 and α_1 involve distinct sets of constraints, at least one constraint of ω_1 must flip rightward past B and another constraint of ω_2 must flip leftward past B. This can't be done in a single flip. [40]

A rank R_p, $0 \leq p \leq n$, thus forms a kind of dispersed image of the $n!$-vertex permutohedron. The *typohedron* of Ψ_n, in which each grammar is represented by a single vertex, with the vertices adjacent if the grammars are adjacent on the permutohedon, takes the form of an n-cube. Suppose we represent it as the n-cube $\{0, 1\}^n$, where each constraint of $\mathbb{X}$ labels a coordinate axis and each vertex $\mathbf{v}_k = (x_{k1}, x_{k2},\ldots, x_{kn})$ is associated with the grammar g_k which has in the UVT of Ψ_n the values $x_{kj} = X_j(g_k)$ for $1 \leq j \leq n$, $X_j \in \mathbb{X}$. The grammars g_k of Ψ_n that belong to rank R_p are then mapped onto the vertices $\mathbf{v}_k$ that are contained in a hyperplane meeting the requirement $\Sigma x_i = n - p$, which is perpendicular to the space-diagonal running from (0, 0, 0) to (1, 1, 1).

We conclude by noting that a pseudo-parametric typology Ψ_n over $\Psi_n.\mathrm{Con} = \mathbb{X} \cup \{B\}$, for $\mathbb{X} = \{X_1,\ldots X_n\}$, has a Property Analysis consisting of all properties

P_i: $Xi <> B$, $1 \leq i \leq n$.

This can be grasped almost immediately from the 'diagonal' representation of the grammars in (44), since each row represents a property.

We can also argue for the Property Analysis from the order structure. Consider any choice of values for the properties P_i, and observe that the a-values $X_i > B$ define $\mathcal{C}_{\mathrm{Top}}$, the b-values $B > X_i$ define $\mathcal{C}_{\mathrm{Bot}}$, and B is placed between the members of $\mathcal{C}_{\mathrm{Top}}$ and $\mathcal{C}_{\mathrm{Bot}}$ in any leg that satisfies this choice of values. Thus each choice of values defines a grammar of the form (42). Conversely, any choice of $\mathcal{C}_{\mathrm{Top}}$ and $\mathcal{C}_{\mathrm{Bot}}$ may be so represented. Since a Property Analysis consists of every choice of values meeting the scope restrictions, of which there are none in this case, it follows that every pseudo-parametric typology is analysable by a PA of this form. □

[40] See Merchant & Prince (2021: ch. 7) on adjacency and transposition.

Bibliography

Alber, Birgit. 2006. Foot. Entry in Keith Brown and Ronald E. Asher (eds.), *Encyclopedia of Language and Linguistics, Elsevier*, Oxford, 539-546.

Alber, Birgit, Natalie DelBusso, and Alan Prince. 2016. From Intensional Properties to Universal Support. *Language: Phonological Analysis* 92.2, e88-e116. ROA-1235.

Alber, Birgit & Alan Prince. 2016. Symmetries and Dependencies in OT Typologies. Slides: 2nd Workshop on the Formal Structure of OT Typologies. University of Verona, June 24.

Alber, Birgit & Alan Prince. 2017. The Structure of OT Typologies as Revealed by Property Analysis. Slides: University of California at Santa Cruz, April 26.

Alber, Birgit & Alan Prince. 2021. *The Structure of OT Typologies*. Chapter 1: Introduction to Property Theory: Chapter 1. ROA-1381.

Alber, Birgit & Alan Prince. In prep. *The Structure of OT Typologies.* Ms: University of Bolzano-Brixen and Typohedron.org.

Bellik, Jennifer, Ozan Bellik, and Nick Kalivoda. 2015-2021. Syntax-Prosody in Optimality Theory (SPOT). Javascript application: http://spot.sites.ucsc.edu. Codebase at https://github.com/syntax-prosody-ot.

Bellik, Jennifer, Junko Ito, Nick Kalivoda, and Armin Mester. To Appear. Matching and Alignment. To appear in Kubozono, Haruo, Junko Ito, & Armin Mester (eds.) *Prosody and Prosodic Interfaces*. Oxford University Press, Oxford Studies in Phonology and Phonetics.

Bellik, Jennifer & Nick Kalivoda. 2018. Prosodic recursion and pseudo-cyclicity in Danish compound stød. https://escholarship.org/uc/item/5p06c4s0. In Ryan Bennett et al. (eds.), *Hana-bana: A Festschrift for Junko Ito and Armin Mester*.

Bellik, Jennifer & Nick van Handel. To appear. Size effects in Prosody: Branch Counting, Leaf Counting, and Uniformity. Ch. 10 of Bellik, Jennifer, Junko Ito, Nick Kalivoda, and Armin Mester, eds., *Syntax-Prosody in Optimality Theory: Theory and Analyses*. Equinox: expected 2024.

Chen, Matthew. 1984/1987. The syntax of Xiamen tone sandhi. *Phonology Yearbook* 4,109–149.

Clark, Mary. 1978. A Dynamic Treatment of Tone Wth Special Attention to the Tonal System of Igbo. Ph. D. Dissertion. University of Masssachusetts at Amherst.

Elfner, Emily. 2012. *Syntax-Prosody Interactions in Irish.* [*Idirghníomhaíochtaí comhréire-prosody*]. PhD dissertation, University of Masschusetts at Amherst. Open Access Dissertations. 505. https://doi.org/10.7275/3545-6n54

Elordieta, Gorka. 1998. Intonation in a pitch-accent dialect of Basque. *International Journal of Basque Linguistics and Philology* 32, 511-569.

Elordieta, Gorka. 2007. A Constraint-based Analysis of restrictions on intonational realization of focus in Northern Bizkaian Basque. In *Tones and Tunes I: Typological Studies in Word and Sentence Prosody*, eds. Tomas Riad and Carlos Gussenhoven, 199-232. Berlin: Mouton de Gruyter.

Ghini, Mirco. 1993. φ-formation in Italian: A new proposal. *Toronto Working Papers in Linguistics* 12, 41 – 78.

Haraguchi, Shosuke. 1977. The tone pattern of Japanese: An autosegmental theory of tonology. PhD Dissertation, MIT.

Hayes, Bruce. 1995. *Metrical Stress Theory: Principles and Case Studies*. U. Chicago Press: Chicago.

Hewitt, Mark 1991. Binarity and Ternarity in Alutiiq. *Proceedings of the Arizona Phonology Conference*, Volume 4. Department of Linguistics, University of Arizona at Tucson. 44-60.

Hewitt, Mark. 1992. *Vertical maximization and metrical theory*. Ph.D. dissertation, Brandeis University.

Hewitt, Mark. 1994. Deconstructing foot binarity in Koniag Alutiiq: University of British Columbia. ROA-12: Rutgers Optimality Archive.

Inkelas, Sharon and Draga Zec. 1995. The phonology/syntax interface. In *Handbook of Phonological Theory*, John A. Goldsmith (ed.), Oxford: Blackwell.

Ishihara, Shinichiro. 2015. Syntax-Phonology Interface. Chapter 14 of Kubozono, Haruo (ed.). *Handbook of Japanese Phonetics and Phonology*. Walter de Gruyter, Berlin/Boston/Munich. 569-618.

Ito, Junko, and Mester, Armin. 1992/2003. Weak Layering and Word Binarity. 1992: Linguistic Research Center, LRC-92-09, University of California, Santa Cruz. 2003: In Honma, Takeru, Masao Okazaki, Toshiyuki Tabata and Shin-ichi Tanaka, eds. *A New Century of Phonology and Phonological Theory. A Festschrift for Professor Shosuke Haraguchi on the Occasion of His Sixtieth Birthday*: 26-65. Kaitakusha: Tokyo.

Ito, Junko and Armin Mester. 2006. Prosodic adjunction in Japanese compounds. *MIT Working Papers in Linguistics* 55, 97-112.

Ito, J., and Mester, A. 2007. Prosodic adjunction. In Japanese compounds, in Miyamoto, Y., and Ochi, M. (eds.) *Formal approaches to Japanese Linguistics: Proceedings of FAJL 4*. Cambridge, MA: MIT Department of Linguistics and Philosophy, 97–111.

Ito, J., and Mester, A. 2009. The extended prosodic word. In Grijzenhout, J., and Kabak, B. (eds.) *Phonological domains: Universals and deviations*. Berlin: Mouton de Gruyter,135–194.

Ito, Junko, and Mester, Armin. 2013. Prosodic subcategories in Japanese. *Lingua* 124, 20-40.

Ito, Junko, and Armin Mester. 2020. Match Theory and Prosodic WellformednessConstraints. In Zhang Hongming and Qian Youyong, eds., *Prosodic Studies: Challenges and Prospects*, 252-274. New York: Routledge Studies in Chinese Linguistics.

Jun, Sun-Ah, and Elordieta, Gorka. 1997. Intonational structure of Lekeitio Basque. In *Intonation: Theory, Model and Applications*, eds. Atonis Botinis, Giorgios Kouroupetroglou and George Carayiannis, 193-196. Athens.

Kalivoda, Nick. 2018. *Syntax-prosody mismatches in Optimality Theory*. Ph.D. Dissertation, University of California, Santa Cruz.

Kalivoda, Nick. To appear. Interactions of Matching, Alignment, and Binarity. In Japanese and Beyond. Ch. 1 of Bellik, Jennifer, Junko Ito, Nick Kalivoda, and Armin Mester, eds., *Syntax-Prosody in Optimality Theory: Theory and Analyses*. Equinox: expected 2023.

Kubozono, Haruo. 1988. *The Organization of Japanese Prosody*, University of Edinburgh:Doctoral dissertation. Published by Kurosio Publishers, Tokyo, 1993.

Kubozono, Haruo. 1989. Syntactic and rhythmic effects on downstep in Japanese. *Phonology* 6, 39-67.

Kubozono, Haruo (ed.). 2015. *Handbook of Japanese Phonetics and Phonology.* Walter De Gruyter: Berlin/Boston/Munich. 2015.

Ladd, D. Robert. 1986. Intonational phrasing: The case for recursive prosodic structure. *Phonology Yearbook*, 3, pp. 311– 340.

Ladd, D. Robert. 1988. Declination 'reset' and the hierarchical organization of utterances. *Journal of the Acoustical Society of America*, 84, pp. 530– 544.

Leer, Jeff. 1985a. Prosody in Alutiiq , in Prosody in Alutiiq (The Koniag and Chugach dialects of Alaskan Yupik). In Krauss M (ed.) *Yupik Eskimo prosodic systems: descriptive and comparative studies*. Fairbanks: Alaska Native Language Center. 77–133.

Leer J (1985b). Evolution of prosody in the Yupik languages. In Krauss M (ed.) *Yupik Eskimo prosodic systems: descriptive and comparative studies*. Fairbanks: Alaska Native Language Center. 135–157.

Leer, Jeff. 1985c. Toward a Metrical Interpretation of Yupik Prosody, in Krauss (1985), ed., 159-172.

Lehiste, Ilse. 1965.The Function of Quantity in Finnish and Estonian. *Language* 41, 447-456.

Lehiste, Ilse. 1966. *Consonant Quantity and Phonological Units in Estonian*, Indiana University Press: Bloomington, Indiana.

Liberman, Mark Y. 1975. *The Intonational System of English*. PhD dissertation, MIT.

Martínez-Parício, Violeta & René Kager. 2015. The binary-to-ternary rhythmic continuum in stress typology: layered feet and non-intervention constraints. *Phonology*, Vol. 32, No. 3, pp. 459-504.

McCarthy, John, and Alan Prince. 1986. Prosodic Morphology 1986. Technical Reports of the Rutgers Center for Cognitive Science 32. New Brunswick, N. J.: Rutgers University. https://ruccs.rutgers.edu/images/tech_rpt/tr-32/pm86all.pdf.

McCarthy, John & Alan Prince. 1993.Generalized Alignment. In Geert Booij & Jaap van Marle (eds.), *Yearbook of Morphology* 1993, 79–153. Dordrecht: Kluwer. ROA-

McCawley, James D. 1968. *The Phonological Component of a Grammar of Japanese*. The Hague, The Netherlands: Mouton.

Merchant, Nazarré and Alan Prince. 2021. The Mother of All Tableaux: Order, equivalence, and geometry in the large-scale structure of OT. ROA-1382. To appear 2023, Equinox Press.

Mester, Armin. 1994. The Quantitative Trochee in Latin. *Natural Language & Linguistic Theory* 12, 1-61.

Myrberg, Sara. 2013. Sisterhood in prosodic branching. *Phonology* 30, No. 1, 73-124.

Nespor, Marina, and Vogel, Irene. 1986. *Prosodic Phonology*. Dordrecht: Foris.

Pierrehumbert, Janet and Mary Beckman. 1988. *Japanese Tone Structure*. Linguistic Inquiry Monograph 15. MIT Press: Cambridge, MA.

Poser, William. 1985. *The phonetics and phonology of tone and intonation in Japanese*. Ph.D. dissertation. MIT. Cambridge: MA.

Prince, Alan. 1980. A Metrical theory for Estonian Quantity. *Linguistic Inquiry* 11.3, 511-562.

Prince, Alan. 2002a. Entailed Ranking Arguments. ROA-500.

Prince, Alan. 2002b. Arguing Optimality. ROA-562.

Prince, Alan. 2006/8. No More than Necessary. ROA-882.

Prince, Alan. 2013. Metrical Theory as a Portal on Theory. Slides: m@90, MIT: Cambridge. Video: YouTube.

Prince, Alan. One Tableau Suffices. 2017. ROA-1250. *Linguistic Inquiry*: rejected.

Richards, Norvin. 2017. *Contiguity Theory*. MIT Press: Cambridge.

Riggle, Jason. 2010. Sampling Rankings. ROA-1075.

Samek-Lodovici, Vieri. 2005. Prosody–Syntax Interaction in the Expression of Focus. *Natural Language & Linguistic Theory* **23,** 687–755. https://doi.org/10.1007/s11049-004-2874-7

Samek-Lodovici, Vieri. 2015. *The Interaction of Focus, Givenness, and Prosody: A Study of Italian Clause Structure*. Oxford University Press: Oxford. https://discovery.ucl.ac.uk/id/eprint/1358320/

Samek-Lodovici, Vieri & Alan Prince. 1999. Optima. ROA-363.

Samek-Lodovici, Vieri & Alan Prince. 2005. Fundamental Properties of Harmonic Bounding. ROA-785.

Selkirk, Elisabeth. 1984. *Phonology and Syntax: the Relation between Sound and Structure*. Cambridge, MA: MIT Press.

Selkirk, Elisabeth. 1986. On Derived Domains in Sentence Phonology. *Phonology Yearbook*, Vol. 3, pp. 371-405.

Selkirk, Elisabeth. 2000. The interaction of constraints on prosodic phrasing. In M. Horne (ed.), *Prosody: Theory and Experiment*. Dordrecht: Kluwer, 231-261.

Selkirk, Elisabeth. 2009. On clause and intonational phrase in Japanese: The syntactic grounding of prosodic constituent structure. *Gengo Kenkyuu* 136, 35-73.

Selkirk, Elisabeth & Gorka Elordieta. 2010. The role for prosodic markedness constraints in phonological phrase formation in two pitch accent languages. Paper presented at the *4th European Conference on Tone and Intonation* (TIE 4), Stockholm University.

Selkirk, Elisabeth. 2011. The syntax-phonology interface. Ch. 14 of *The Handbook of Phonological Theory. 2nd edition*: pp. 435-484. John Goldsmith, Jason Riggle and Alan Yu, eds. 2011. Oxford: Blackwell Publishing.

Truckenbrodt, Hubert. 1995. *Phonological phrases: Their relation to syntax, focus and prominence.* Ph.D. dissertation, Department of Linguistics, MIT.

Truckenbrodt, Hubert. 1999. On the relation between syntactic phrases and phonological phrases. *Linguistic Inquiry* 30, 219-256.

Vance, Timothy J. 2008. The Sounds of Japanese. Cambridge, U.K.: Cambridge University Press.

Zubizarreta, Maria Luisa. 1994. On Some Prosodically Governed Syntactic Operations. In Guglielmo Cinque, Jan Koster, Jean Yves Pollock, Luigi Rizzi, & Raffaella Zanuttini (eds.), *Paths toward Universal Grammar. Studies in Honor of Richard S. Kayne*. Washington: Georgetown University Press, 473–85.

Zubizarreta, Maria Luisa. 1998. *Prosody, Focus, and Word Order*. Cambridge, MA: MIT Press.