A Constraint Definition Language for markedness constraints and consequences for stress placement

Nate Koser
nate.koser@rutgers.edu
Rutgers University

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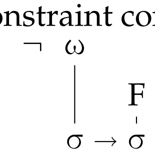
1 Introduction

This paper posits a theory of stress assignment in Optimality Theory (Prince and Smolensky 1993) with a theory of CON that posits that markedness constraints are only local bans on forbidden substructures. This approach is taken because it is an explicit claim about the *Constraint Definition Language* (Eisner 1997; de Lacy 2011), or CDL, for markedness constraints. It is a theory of the mechanisms of the grammar used in constructing and evaluating constraints that ultimately determines which constraints can be written and which ones cannot. de Lacy states that: "An explicit CDL is both useful and ultimately essential to a complete Optimality Theory." (p.1494). While researchers would likely agree that allowing any logically possible constraint is too permissive, formal discussion of how the space of CON should be restricted is surprisingly scarce.

This paper assumes a theory of markedness where the CDL is limited to local bans only. Markedness generalizations are about the ill-formedness or improper arrangement of phonological elements. In OT, markedness constraints are the theory-internal instantiation of markedness generalizations. The content of markedness constraints is not arbitrary. In fact, they are overwhelmingly bans on forbidden structures (McCarthy and Prince 1993; Jardine and Heinz 2016). Examples of such constraints include *CODA and *CLASH. *CODA is violated when the coda position of a syllable is occupied. *CLASH is violated when a string of two stressed syllables occurs. These constraints do not require structures or consider distant elements in a candidate. They only check for an illicit local structure and assign a violation when the structure is present. Many markedness constraints seen in the literature are of this form.

This adherence to locality is formalized by positing that the constraint definition language for markedness constraints is *conjunctions of negative literals* (Rogers et al. 2013), or CNLs, a term from formal language theory explained more fully in §2. For now it is enough to know that CNL constraints can only ban forbidden substructures of phonological structure (metrical structure, in the case taken up here). A formal language theory approach is useful in that it gives us a way to evaluate the properties of constraints in a well-understood hierarchy of complexity that is independent from OT itself. An example of a CNL constraint posited in this paper is given in (1):

(1) ¬ ωF constraint

constraint name	constraint content
¬ *ωF*	

¬ω*F* and its counterpart ¬*F*ω are similar to the constraints **Ft/_σ* and **Ft/σ_* discussed in McCarthy (2003), but are defined as CNLs here. ¬ω*F* is violated when an unfooted syllable is immediately followed by a syllable that is footed, and ¬*F*ω is the opposite case.

The rejection of more complex constraints via the adoption of a CNL only CDL has important consequences for traditional theories of placement of feet and stress. One constraint that is absent from CON if CON is limited to CNLs is ALIGN (McCarthy and Prince 1993):

(2) ALIGN(Cat1, Edge1; Cat2, Edge2; Cat3):
∀ Cat1 ∃ Cat2 such that Edge1 of Cat1 and Edge2 or Cat2 coincide. Assign one violation mark ∀ Cat3 that intervenes between Edgel of Catl and the nearest Edge2 of some Cat2

Adopting a CNL theory of markedness is an assertion that foot placement is the result of local pressures, not distance-sensitive edge alignment. No conjunction of banned structures can have the same effect as ALIGN, which uses first-order quantification. Arrangement of feet is instead encouraged via constraints of the form in (1).

Below it is shown in detail that this conception of stress assignment is sufficient to capture a wide range of attested stress patterns. Following Gordon (2002)'s typology of quantity-insensitive stress (i.e. languages where syllable weight does not factor into stress placement), 90% of languages are accounted for.

One interesting result that emerges from selection of a low-complexity CDL concerns OT optimization. It will be shown that even when CON is limited to CNL logic, adding optimization allows for generation of much higher complexity patterns. If optimization generates patterns of a higher complexity than what is selected for the CDL, then it is not clear if proposing a maximally simple CDL has any theoretical benefits.

However, while referring to a higher level of expressive power is unnecessary to capture the target patterns, there are interesting theoretical consequences to limiting the constraint definition language to CNLs. The CNL constraint set predicts the existence of many unnatural, sometimes pathological patterns as well.

A theme runs through the unattested patterns – extreme sensitivity to word length with regards to stress placement that does not mirror natural language. In natural language, stress placement proceeds in a similar fashion regardless of word length. The unattested patterns in this stress typology do not adhere to this principle. There are also cases of ambiguity where local constraints fail as the word grows longer. This can be interpreted as a flaw with adherence to CNL-only constraints, and suggests that some distance-sensitivity may be necessary in theories of stress.

In some cases, the sensitivity to word length is extreme, including cases of "sour grapes"-like stress where feet fail to iterate only in even-numbered syllable words. These cases are interesting in their own right – the sour grapes patterns present in the typology are, in the formal sense, regular. Regular patterns are describable by a finite-state automaton or regular expression (Yu 1997; Hopcroft et al. 2006). A proof can be formulated showing that the pattern is not star-free – the first level of logical complexity below the level of regular (McNaughton and Papert 1971; Rogers and Pullum 2011a). The result, then, is identification of a property of OT optimization alluded to above that is as of yet unarticulated: optimization over candidates with CNL constraints can produce fully regular patterns. This jump in complexity is noteworthy. CNLs are the lowest level of logical complexity, but there is still a a constellation of pathological patterns in the typology. It is possible that a more powerful logic for the CDL is needed to constrain overgeneration.

The paper is organized as follows: §2 gives some background on the formalisms adopted throughout the proposal. In §3 I delve into the placement of feet within a word in quantity insensitive languages under the theory posited here. §4 examines the ways in which this theory overgenerates and discusses the implications of the overgeneration. §5 discusses the results of the paper and §6 is a conclusion.

2 Methods and Representations

2.1 Measuring Constraint Complexity in Logic

In formal language theory, there is a well-understand hierarchy of logical languages, organized in terms of the complexity or expressive power available at each level. Definition of OT constraints using formal language theory terms makes the expressive power of the constraint explicitly clear. The following chart is a visual representation of (a subsection of) the logical complexity hierarchy:

(3) hierarchy of logical languages (Jardine and Heinz 2016)

First-order logic
|
Propositional logic
} require and ban structures
|
conjunctions of negative literals } ban structures

Here, stress assignment is cast as a local phenomenon. This is done by defining constraints as CNLs. A negative literal is a representation accompanied by a negation symbol, $\neg$, indicating that the represented structure is banned. These negative literals can be joined by conjunction, represented by the symbol $\wedge$. Here, the representations will be over metrical structure, and these conjunctions will comprise constraints banning illicit configurations of prosodic elements. The constraints will be of the form $\neg\, a \wedge \neg\, b \wedge \neg\, c$ where *a*, *b*, and *c*, are prosodic elements/structures that are banned by (incur violations of) the constraint. As an example of a constraint defined in this way, consider *CLASH. *CLASH would be defined as ¬ˈσˈσ - a ban on two consecutive stressed syllables.

This is the limit of the power of CNLs. As shown in the chart, they occupy the lowest space possible in the complexity hierarchy. Only constraints that ban structures can be formulated at that level. The ability to have more powerful constraints would require a CDL with at least Propositional Logic. Whereas CNLs only allow the negation of lone elements, Propositional Logic allows the negation of expressions as well. So, in addition to $\neg a \wedge \neg b \wedge \neg c$, we could have $\neg (\neg a \wedge \neg b \wedge \neg c)$, which requires at least one of either a, b, or c to be true. This is more expressive than CNLs (Rogers et al. 2013). First-Order Logic is more powerful still, introducing quantification over variables of the sort seen in the definition of ALIGN in (2). This logical approach to the complexity of constraints makes it clear that a CNL constraint definition language is necessarily much less powerful than a CDL using First-Order Logic. The potential consequences of a more powerful CDL are discussed in the next subsection.

2.2 More powerful CDL and potential consequences

A CDL that has access to higher levels of expressive power than CNLs has potential undesirable consequences. Take the ALIGN-schema constraints, defined above in (2) as an example. These constraints can produce an effect known as the Midpoint Pathology as a direct result of the First-Order Logic quantification in their definition. The following tableau, adapted from Hyde (2012), provides an example of the phenomenon, using an ALIGN constraint demanding that the left edge of every syllable align with the left edge of some foot. Commas separate violations by the locus of violation to which they were assigned:

(4)

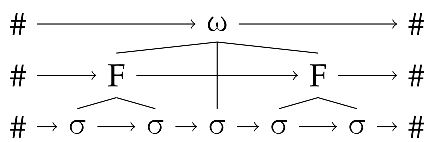
/σσσσσσσ/	ALIGN(σ, L, F, L)
a. (σσ)σσσσσ	*,**,***,****,***!**,******
b. σ(σσ)σσσσ	*,*,**,***,****,**!***
c. σσ(σσ)σσσ	**,*,*,**,***,****!
☞ d. σσσ(σσ)σσ	***,**,*,*,**,***
e. σσσσ(σσ)σ	****,***,**,*,*,**!
f. σσσσσ(σσ)	*****,****,***,*!*,*,*

With the foot in the middle of the word, the violations counted at each locus of violation are less severe than in any other candidate. The typologically unattested preference to place exactly one foot in the middle of a word is the result of the universal quantification over the prosodic categories - every misaligned syllable exerts pressure to be closer to the foot edge at the same time. Limiting the CDL of this theory of stress to CNLs avoids typological prediction of this pathological pattern, though it will be shown that the typology of CNL stress constraints contains unnatural patterns of its own.

2.3 Metrical Structure and Representations

It is necessary to establish the metrical structure underlying the proposal here, as the constraints will refer to the structure explicitly:

(5) Metrical Structure



The uppermost tier is the Prosodic Word tier. It is occupied by Prosodic Words, represented with a ω. This dominates the Foot tier, which is occupied by feet, represented with an *F*. This dominates the syllable tier, which is occupied by syllables, represented with a σ. Syllables may also be directly dominated (i.e. "parsed") by a Prosodic Word. Each tier is wrapped in #s, which represent the edge of that tier. The arrows in the diagram represent a successor relationship between elements on a tier. For more on metrical structure and the prosodic hierarchy, see Nespor and Vogel (1986) and Selkirk (1984). I assume culminativity - GEN will not produce candidates with no feet or no stresses. GEN will also not produce candidates with feet larger than two syllables e.g. ternary feet.

Other proposals explicitly (Hyde 2012) or implicitly (Kager 2001, 2005; McCarthy 2003) maintain that distance-sensitivity is indispensable in theories of stress. Hyde (2012) states: "Distance-sensitive alignment actually is a necessary component of the theory" (p. 790). But this notion of distance-sensitivity is poorly-defined. The formal language theory terms *successor relation* and *precedence relation* (see Heinz (2010)) can be used to clarify. Two elements are in a successor relationship if one *immediately* follows the other. On the other hand, two elements are in a precedence relationship if one follows the other *at any point*. Precedence relationships hold over a distance, and thus can be non-local. So, if a pattern must be described using only the successor relation, then that pattern is local. If a pattern requires use of precedence in the definition of a constraint, then it is distance-sensitive. This gives a clear diagnostic for this aspect of stress patterns. As this theory of stress is local-only, constraints and representations throughout this paper will only refer to successorship. In formal language theoretic terms, CNL logic with the successor relation defines the strictly local (SL) languages for strings (McNaughton and Papert 1971), though this paper refers to non-string structures.

The constraints in this proposal will be CNL constraints defined over the metrical structure in (5). In addition to ¬ω*F*, described above in (1), its counterpart ¬*F*ω also serves to motivate placement of feet. I define them both as CNLs in (6) and provide a small tableau for clarity in (7):

(6) Constraint: ¬ ωF ¬ Fω

(7)

/σσσσσσσ/	¬ωF	¬Fω
☞ a. (σσ)(σσ)(σσ)σ		∗
b. σ(σσ)(σσ)(σσ)	∗!	
c. (σσ)σ(σσ)(σσ)	∗!	∗
d. (σσ)(σσ)σ(σσ)	∗!	∗

¬ω*F* is violated when a footed syllable is the successor to an unparsed syllable. ¬*F*ω is the opposite case – violation occurs when a footed syllable is immediately followed by a syllable that is unfooted. Note that these constraints are not sensitive to a left or right edge - candidates (d) and (e) suffer equal violations of both ¬ω*F* and ¬ *F*ω for breaking a string of feet up with an unparsed syllable. Though the two candidates differ in where the unparsed syllable goes, their violation profiles are identical. In §3, we will see that $\neg\omega F$ and $\neg F\omega$, along with other familiar constraints on metrical structure, are able to account for a wide range of patterns described in Gordon's typology.

To briefly recap - a CNL conception of markedness constraints, following Jardine and Heinz (2016) has several advantages. It gives us a clear idea of the makeup of CON - something that Eisner (1997) and de Lacy (2011) argue is lacking. It also frees us from some unwanted typological predictions made by constraints in theories with a more powerful CDL. Having laid the theoretical ground work, the next section turns to the placement of stress within this theory.

3 Stress Placement

3.1 Typology

This paper focuses on a subset of the patterns in Gordon (2002)'s typology of quantity insensitive stress. The goal is to provide an analysis of "core" attested stress patterns that is still informative as to the consequences of the adopted CDL and still captures a large percentage of well-known patterns. Zooming in on relatively simple cases of stress assignment will make the contents of the typology easier to understand. To this end, the analysis here is limited to *single stress* systems and *iterative binary stress* systems. These two systems are selected partly for their typological frequency – they comprise 90% of Gordon's typology – and partly for their intuitive nature – they are relatively simple and easily understood. Any account of stress will need to address these patterns, and so they make a good foundation for analysis of a given constraint set's typology. Additionally, this account of stress will not consider primary versus secondary stress. Only the distinction between stressed an unstressed will be examined.

3.2 Constraints

The following is the set of constraints for this theory of stress assignment in single stress and iterative binary stress patterns. Prose definitions are given alongside CNL definitions.

(8) constraint set

- $\neg\omega F$: violated when an unfooted syllable follows a footed one; see (6)
- $\neg F\omega$: violated when a footed syllable follows an unfooted one; see (6)
- FTBININITIAL : violated by an initial unary foot; see (17) CONJB
- FTBINMID: violated by a unary foot between two other feet; see (17) CONJA
- FTBINFINAL : violated by a final unary foot; see (17) CONJC
- IAMB : violated by trochees and unary feet; ¬ (ˈσσ) ∧ (ˈσ)
- TROCHEE : violated by iambs and unary feet; ¬ (σˈσ) ∧ (ˈσ)
- *LONGLAPSE: violated by 3 successive unstressed syllables; ¬ σ̆σ̆σ̆
- *LONGLAPSERIGHT: as *LONGLAPSE but at the right edge; ¬ σ̆σ̆σ̆#
- *INITIALLAPSE: violated by 2 unstressed syll at left edge; ¬#σ̆σ̆

Each constraint is written as a conjunction of negative literals. There are several points of interest. One is the presence of positional versions of FTBIN, banning a unary a foot in a specific position in a word. It is also noteworthy that the constraint set lacks any PARSE constraint. Here, other constraints, such as the positional anti-lapse constraints, motivate fuller parses. These two observations will be expanded on in the discussion of binary stress. Another point is that IAMB and TROCHEE will serve as *foot antagonists* in this theory of stress. The two constraints, working together, can limit creation of feet in a word to one with the proper ranking. This will be shown in the discussion of single stress.

Examination in OTWorkplace (Prince et al. 2007 2017) reveals a typology of 60 unique languages for these ten constraints. In this typology, all attested single stress patterns and iterative binary patterns are present. Discussion of languages in the typology that are not attested is saved for a later section.

3.3 Single stress

Single stress languages are languages where stress predictably falls on a syllable at a certain distance from an edge in words of all lengths. Gordon, along with Hyman (1977), note that of all the logically possible placements of a single stress within a word, only five patterns emerge typologically: initial stress, peninitial stress, antepenultimate stress, penultimate stress, and final stress. Both Gordon and Hyman note a large number of initial, final, and penultimate patterns, while peninitial and antepenultimate patterns are rarer. All together, single stress patterns account for 70% of the languages in Gordon's typology. Hasse diagrams for each pattern can be found in the Appendix.

3.3.1 Initial stress

Initial stress is predictable stress on the first syllable regardless of word length. Initial stress languages comprise around 30% of the single stress languages in Gordon's typology. Nenets (Decsy 1966) is an example. Intuitively, initial stress will occur when a trochee is placed on the left edge. The following comparative OT tableau (Prince 2002) shows how this pattern emerges in this theory of stress.

(9) initial stress

input	winner	loser	¬ωF	FtBinInit	FtBinMid	FtBinFin	*InitLapse	Troch	Iamb	¬Fω	*LL	*LLR
3syll	(ˈσσ)σ	σ(ˈσσ)	W							L		
4syll	(ˈσσ)σσ	σ(ˈσσ)σ	W								L	L
2syll	(ˈσσ)	(σˈσ)						W	L			
4syll	(ˈσσ)σσ	(ˈσσ)(ˈσσ)							W	L	L	L

The ¬ω*F* constraint demands that the single foot be on the left edge of the word, despite ¬*F*ω and *LongLapse's preference for the losing candidate. No unary feet are allowed. *InitialLapse is satisfied by the placement of the foot. Trochee crucially outranks Iamb. This results in the creation of trochaic feet only. Iamb, however, is not inactive. Having trochees satisfies higher-ranked Trochee, but any attempt to create more than one trochaic foot fatally violates Iamb. This is the effect of *foot antagonism* mentioned above. The higher-ranked foot type constraint determines the shape of output feet, but the opposite foot type constraint, ranked just below it, limits the number of these feet to just one, even though creation of more feet would better satisfy ¬*F*ω, *LongLapse, and *LongLapseRight in this case.

3.3.2 Peninitial stress

Peninitial stress is predictable stress that falls on the second syllable in a word regardless of word length. Peninitial stress languages represent around 5% of languages in Gordon's typology. An example is Lakota (Boas and Deloria 1941). Peninitial stress occurs when an iamb is on the left edge of the word. The following tableau demonstrates how the peninitial pattern arises in this theory.

(10) peninitial stress

input	winner	loser	¬ωF	FtBinInit	FtBinMid	FtBinFin	*InitLapse	Iamb	Troch	¬Fω	*LL	*LLR
5syll	(σˈσ)σσσ	σσσ(σˈσ)	W				W			L	W	L
5syll	(σˈσ)σσσ	σ(σˈσ)σσ	W				W				L	L
2syll	(σˈσ)	(ˈσσ)						W	L			
4syll	(σˈσ)σσ	(σˈσ)(σˈσ)							W	L		
5syll	(σˈσ)σσσ	(σˈσ)(σˈσ)σ							W		L	L

In peninitial stress patterns high-ranked ¬ω*F* requires the single foot to be on the left edge of the word. This could also be interpreted as the force of *InitialLapse, as having the iambic foot anywhere else would result in a lapse at the left edge. No unary feet are tolerated. Iamb crucially outranks Troch, resulting in iambs on the surface. However, creation of additional iambs accrues further violations of Troch, and so the number of iambic feet is limited to one, even though the lower-ranked constraints against long lapses would prefer the loser. This mirrors the situation in initial stress languages as described above and is another example of the foot-antagonistic properties of the Iamb and Troch constraints.

3.3.3 Penultimate stress

Penultimate stress languages are those where the stress predictably falls on the penultimate syllable, regardless of word length. Penultimate stress patterns comprise around 29% of the single stress languages in Gordon's typology. An example is Albanian (Hetzer 1978). A trochee on the right edge of the word yields penultimate stress. The tableau in (11) shows how this is achieved.

(11) penultimate stress

input	winner	loser	¬Fω	FtBinInit	FtBinMid	FtBinFin	*LLR	Troch	Iamb	¬ωF	*InitLapse	*LL
3syll	σ(ˈσσ)	(ˈσσ)σ	W							L		
4syll	σσ(ˈσσ)	σ(ˈσσ)σ	W								L	
5syll	σσσ(ˈσσ)	σσ(ˈσσ)σ	W									L
2syll	(ˈσσ)	(σˈσ)						W	L			
4syll	σσ(ˈσσ)	(ˈσσ)(ˈσσ)							W	L	L	
5syll	σσσ(ˈσσ)	σ(ˈσσ)(ˈσσ)							W		L	L

High-ranked ¬*F*ω requires that the feet be flush with the right edge of the word. No unary feet are allowed. This arrangement also satisfies *LongLapseRight, as the penultimate position of stress places it near the right edge. Looking at Troch and Iamb, we see again the effect of foot antagonism. Higher-ranked Troch requires that output feet be trochees, but Iamb, crucially ranked above ¬ω*F*, *InitialLapse, and *LongLapse ensures that the number of trochees is maximally one. If Iamb did not outrank the three constraints in the lowest stratum, placement of additional feet would be tolerated in order to satisfy ¬ω*F*, *InitialLapse, and/or *LongLapse.

3.3.4 Final stress

In final stress languages, a single stress predictably falls on the final syllable in all words. Final stress languages make up around 32% of the single stress languages in Gordon's typology. An example is Atayal (Egerod 1966). Final stress is the result of the formation of an iamb on the right edge of the word. The tableau below in (12) demonstrates this.

(12) final stress

input	winner	loser	¬Fω	FtBinInit	FtBinMid	FtBinFin	*LLR	Iamb	Troch	¬ωF	*InitLapse	*LL
4syll	σσ(σˈσ)	(σˈσ)σσ	W							L	L	L
2syll	(σˈσ)	(ˈσσ)						W	L			
4syll	σσ(σˈσ)	(σˈσ)(σˈσ)							W	L	L	L

The highly-ranked ¬*F*ω ensures that the foot is placed on the right edge. No unary feet are tolerated. The ranking of IAMB over TROCH guarantees iambs on the surface, but the now-familiar foot antagonistic property of the two constraints (TROCH in this case) limits the creation of feet to just one. ¬ω*F*, *INITIALLAPSE, and *LONGLAPSE are all outranked by TROCH and cannot force the placement of additional feet. A single iamb is placed on the right edge resulting in a final stress pattern.

3.3.5 Antepenultimate stress

Antepenultimate stress languages are those where stress predictably falls on the antepenultimate syllable of a word. These types of stress patterns comprise less than 4% of the single stress languages in Gordon's typology. An example is Macedonian (Lunt 1952). An antepenultimate stress pattern arises when a trochee sits one syllable removed from the right edge. This places the stress on the third syllable from the right.

So far in the discussion of single stress, the constraints ¬ω*F* and ¬*F*ω have served crucial roles in locating the lone foot. When one is highly ranked, the foot is obliged to form on the relevant edge of the word, preventing a gap of unparsed syllables. But in an antepenultimate pattern, there is necessarily a gap between the foot edge and the word edge. For any form longer than three syllables, ¬ω*F* and ¬*F*ω will be equally violated by the surface form, as the foot will have an unparsed gap to its left and right. How, then, does an antepenultimate stress pattern arise in this theory of stress? The tableau below in (13) is informative.

(13) antepenultimate stress

input	winner	loser	FtBinInit	FtBinMid	FtBinFin	*LLR	Troch	Iamb	¬ωF	*InitLapse	*LL	¬Fω
4syll	σ(ˈσσ)σ	(ˈσσ)σσ				W			L		W	
5syll	σσ(ˈσσ)σ	σ(ˈσσ)σσ				W				L	W	
2syll	(ˈσσ)	(σˈσ)					W	L				
4syll	σ(ˈσσ)σ	(ˈσσ)(ˈσσ)						W	L			L
5syll	σσ(ˈσσ)σ	σ(ˈσσ)(ˈσσ)						W		L		L
6syll	σσσ(ˈσσ)σ	σσ(ˈσσ)(ˈσσ)						W			L	L
3syll	(ˈσσ)σ	σ(ˈσσ)							W			L
4syll	σ(ˈσσ)σ	σσ(ˈσσ)								W		L
5syll	σσ(ˈσσ)σ	σσσ(ˈσσ)									W	L

All forms must obey highly-ranked *LongLapseRight, preventing a string of three unstressed syllables at the right edge. Troch outranks Iamb, resulting in surface trochees, but again the foot antagonistic nature of the Iamb constraint ensures that only one foot can be placed. In the trisyllabic form, the initial syllable is also the antepenultimate syllable, and ¬ω*F* places the trochee on the left edge.

Of crucial importance for the derivation of the pattern is the outranking of ¬*F*ω by both *InitialLapse and *LongLapse. While aligning the right edge of the foot and the word would satisfy both ¬*F*ω and higher-ranked *LongLapseRight, doing so would fatally create additional lapses to the left of the foot – an initial lapse in the four syllable form, and a long lapse in the five syllable form.

The restrictions on lapses imposed by the constraints are what allow the antepenultimate pattern to appear typologically in this theory of stress. Emerging as a kind of lapse avoidance sets the pattern apart from its other single stress counterparts, which arise as the result of the relative ranking of the ¬ω*F*, ¬*F*ω, Troch and Iamb constraints instead. This divergence of the antepenultimate pattern from the other attested single stress archetypes is interesting, and not unusual – Hyde (2012, p. 823) proposes a Final-Window constraint, which limits the stress to a three-syllable window at the right edge, to account for such patterns. Gordon (2002) employs a constraint *ExtLapseRight (p. 503) to similar ends. Both of these are functionally identical to the *LONGLAPSERIGHT constraint used here (though Hyde's constraint allows gradient evaluation). This approach differs, however, in that it makes no reference to an ALIGN family constraint. Both Hyde and Gordon employ a gradient ALIGN-type constraint that is most satisfied when the main stress syllable is aligned with the left edge of the word. Ranked below the "window" constraint, the ALIGN constraint can pull the stress left – but not beyond the final three syllables. Stress is placed on the antepenultimate syllable as the result of a tug-of-war between the two constraints. What has been shown here is that reference to ALIGN is not necessary – antepenultimate stress occurs as the result of pressure to avoid lapses.

This section demonstrated the ability of a categorical negative literal-only constraint set to capture all attested single stress patterns. For initial, peninitial, penultimate, and final stress, re-ranking of the constraints $\neg\omega F$, $\neg F\omega$, TROCH and IAMB with respect to each other allowed the patterns to emerge. For antepenultimate stress, important decisions in words of several syllables or more fall to the lapse constraints, with the penultimate syllable being the location for stress that best avoids initial and long lapses. The discussion now turns to iterative binary stress systems.

3.4 Iterative binary stress

In iterative binary systems stress is assigned to every other syllable. What this means in metrical theories of stress is placement of trochees or iambs starting at the left or right edge, continuing to the end of the word. In the case of an odd-numbered syllable form, languages differ on whether they allow placement of a unary foot, or whether strict foot binarity is enforced. The iterative binary patterns constitute roughly 20% of all languages present in Gordon (2002)'s typology. Trochees are heavily favored over iambs (45 trochaic languages vs. 9 iambic languages).

Pintupi (Hansen and Hansen 1969) is an example of an iterative binary pattern – trochees are built from left to right, and only binary feet are allowed.

(14) Pintupi stress
(ˈσσ)
(ˈσσ)σ
(ˈσσ)(ˈσσ)

(ˈσσ)(ˈσσ)σ
(ˈσσ)(ˈσσ)(ˈσσ)
(ˈσσ)(ˈσσ)(ˈσσ)σ

Murinbata (Street and Mollinjin 1981) is like Pintupi, but also permits the formation of unary feet. This is what is referred to as an *exhaustive* parse – all syllables are parsed to feet.

(15) Murinbata stress
(ˈσσ)
(ˈσσ)(ˈσ)
(ˈσσ)(ˈσσ)
(ˈσσ)(ˈσσ)(ˈσ)
(ˈσσ)(ˈσσ)(ˈσσ)
(ˈσσ)(ˈσσ)(ˈσσ)(ˈσ)

For binary stress systems, all permutations of directionality of foot placement (left to right), foot type (trochee or iamb), and parse level (exhaustive or non-exhaustive) are attested except for the right-to-left non-exhaustive iambic pattern.

What motivates the placement of additional feet as opposed to the single foot seen in single stress systems above? Traditionally a high-ranked PARSE constraint could instigate the creation of additional feet. However, as noted in §3.2, the constraint set of this theory of stress lacks a PARSE constraint. What, then, is the motivation for a fuller parse in this system? An analysis of these patterns begins below.

3.4.1 Non-exhaustive binary stress

Among binary stress systems, non-exhaustive languages build trochees or iambs in one direction from the left or right, but do not allow unary feet. Pintupi above in (14) is an example of left-to-right non exhaustive binary trochee assignment. Warao (Osborn 1966) is an example of its right-to-left counterpart – trochees are built from right to left. Araucanian (Echeverria and Contreras 1965) provides an example of left-to-right iambs, while its right-to-left reflection is, as noted above, unattested. The following tableau demonstrates how the Pintupi pattern emerges in this theory of stress.

(16) Pintupi stress

input	winner	loser	¬ωF	FtBinInit	FtBinMid	FtBinFin	*InitLapse	*LL	*LLR	Troch	¬Fω	Iamb
3syll	(ˈσσ)σ	σ(ˈσσ)	W								L	
4syll	(ˈσσ)(ˈσσ)	σ(ˈσσ)σ	W								W	L
3syll	(ˈσσ)σ	(ˈσ)(σˈσ)		W						W	L	
5syll	(ˈσσ)(ˈσσ)σ	(σˈσ)(ˈσ)(σˈσ)			W					W	L	L
3syll	(ˈσσ)σ	(σˈσ)(ˈσ)				W				W	L	
5syll	(ˈσσ)(ˈσσ)σ	(ˈσσ)σσσ						W	W			L
2syll	(ˈσσ)	(σˈσ)								W		L

The ¬ω*F* constraint is instrumental in placing the left edge of the feet on or as close as possible to the left edge of the word. The FtBin constraints disallow unary feet in any position. The arrangement of feet satisfies *InitialLapse. It is also now apparent what motivates the creation of additional feet – the *LongLapse and *LongLapseRight constraints. Without the placement of more feet, and therefore stress, long lapses between stressed syllables and the word edge would appear. In order to avoid fatal violation of these constraints, more syllables are parsed to feet, where they can bear stress and break up the unwanted lapses. Whereas past accounts treated fuller parsing as the result of a Parse constraint, here it is cast as lapse avoidance.

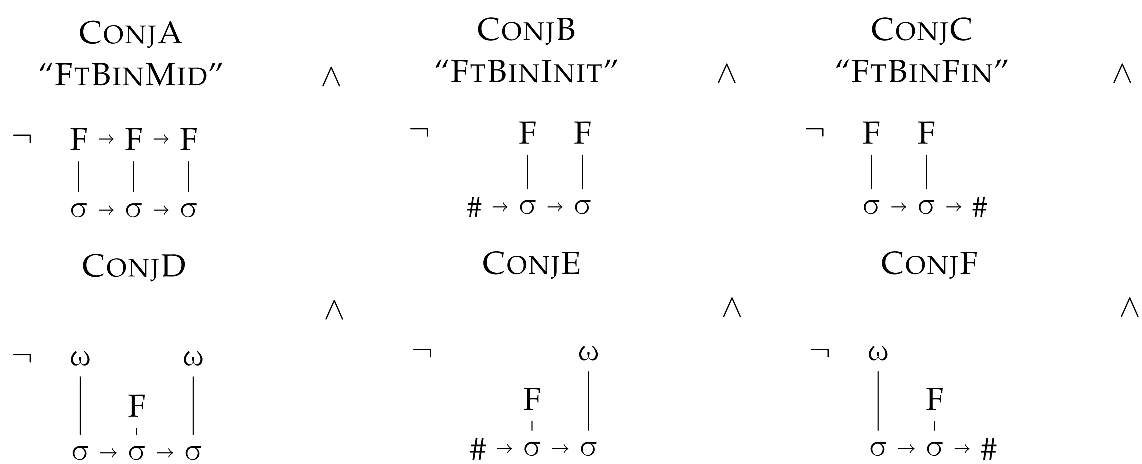
This is the ranking for Pintupi. A permutation of ¬ω*F* and ¬*F*ω in the hierarchy results in a Warao-type stress pattern. The ranking of Araucanian is that of Pintupi, but with the locations of Troch and Iamb in the hierarchy switched, Araucanian also showing left-to-right directionality but preferring iambs instead. From that point, a further switch of ¬ω*F* and ¬*F*ω results in the unattested right-to-left iambic pattern. Discussion of unattested patterns predicted by this theory of stress is saved for §4.

3.4.2 Exhaustive binary stress

Exhaustive binary stress languages build trochees or iambs in one direction from left to right and fully parse every syllable to a foot, resulting in the creation of unary feet in words with an odd number of syllables. A left-to-right parse isolates the unary foot at the right edge, and a right-to-left parse isolates it at the left edge. The Murinbata pattern in (15) is an example of left-to-right exhaustive trochaic parsing. A right-to-left counterpart of Murinbata is Biangai (Dubert and Dubert 1973). For iambs, Ojibwa (Kaye 1973) provides an example of a left-to-right exhaustive pattern, while Weri (Boxwell and Boxwell 1966) is the right-to-left mirror image.

Above it was shown that for both single stress systems and binary non-exhaustive systems, the $\neg\omega F$ and $\neg F\omega$ constraints play an important role in the placement of feet. By banning an unparsed syllable gap between feet and word edges, the two constraints can induce word-edge alignment of feet on the right or left, depending on their relative ranking. But in the case of exhaustive parse systems, every syllable is parsed to a foot. What can determine where the unary foot is to be placed within a word? Traditional accounts used ALIGN-type constraints demanding that all feet align with a specified edge (see Kager 2007, p. 208). Under that kind of analysis, placing the unary foot at the relevant edge then also brings the other feet closer to that edge (one syllable distance to the next foot versus two). Here, however, there are no ALIGN constraints, and any placement of the unary foot equally satisfies both $\neg\omega F$ and $\neg F\omega$. Some other method of distinguishing unary foot placements is needed. FTBIN, defined as a conjunction of negative literals, provides a solution.

(17) FTBIN as a CNL



The banned structures in conjuncts A through H in (17) represent all logically possible locations for a unary foot given the metrical structure in (5). Since a CNL FtBin cannot require binary feet, all potential manifestations of unary feet are banned instead. Note that this definition is not a departure from or evolution of traditional FtBin – this is the same well-known FtBin from stress literature explicitly defined as a CNL.

Each conjunct, considered in isolation, is a *positional* FtBin – a positional markedness constraint that is violated in a narrower context than FtBin as a whole. This type of reanalysis is not unfamiliar in the literature – consider the use of *ComplexOnset and *ComplexCoda instead of the more general *Complex. The consequence for stress assignment, then, is that exhaustive binary languages are sensitive to these positional FtBin requirements – conjuncts A, B, and C, which have been named FtBinMid, FtBinInitial, and FtBinFinal, respectively, are independent constraints in Con that can be ranked with respect to each other.[1] Dividing FtBin into three independently rankable constraints allows for a straightforward analysis of binary exhaustive stress patterns.

(18) Murinbata

input	winner	loser	¬ωF	¬Fω	FtBinInit	FtBinMid	*InitLapse	*LL	*LLR	FtBinFin	Troch	Iamb
3syll	(ˈσσ)(ˈσ)	σ(ˈσσ)	W							L	L	L
3syll	(ˈσσ)(ˈσ)	(ˈσσ)σ		W						L	L	L
3syll	(ˈσσ)(ˈσ)	(ˈσ)(ˈσσ)			W					L		
5syll	(ˈσσ)(ˈσσ)(ˈσ)	(ˈσσ)(ˈσ)(ˈσσ)				W				L		
2syll	(ˈσσ)	(σˈσ)									W	L

[1]Referring back to (8) one might notice that FtBin is missing from the constraint set completely. Studying the typology in OTWorkplace shows that once the three positional variants proposed here are included, adding or removing “standard” FtBin has no effect on the predicted typology.

For accurate placement of the unary foot in Murinbata, it is crucial that FTBININITIAL and FTBINMID outrank FTBINFINAL. This allows the unary foot to appear at the end – while Murinbata will tolerate a final unary foot, an initial or word-medial foot cannot surface. In this way, the positional FTBIN constraints can account for foot placement in iterative binary exhaustive parse languages.

Also note how the exhaustive parse is achieved – in the discussion of non-exhaustive binary stress, it was shown that lapse constraints can motivate the placement of additional feet – not a PARSE constraint. However, in the case of an exhaustive parse, lapse constraints alone cannot parse every syllable to a foot. They can only force the minimal parse that avoids a lapse. While $\neg \omega F$ and $\neg F \omega$ have no say in the placement of unary feet, (18) shows the crucial role they play in ensuring a full parse. Ranked in the top stratum, the two constraints are most satisfied when there are no unparsed gaps between word edges and foot edges at all. Working together, a full parse is enforced – something the lapse constraints alone could not do.[2]

Simple reranking of constraints in the hierarchy for Murinbata allows for the derivation of other iterative binary exhaustive patterns as well. Reranking IAMB above TROCH results in the Ojibwa pattern of left-to-right iambs. The Biangai pattern of right-to-left exhaustive trochees arises when the location of FTBININIT and FTBINFIN in (18) are switched. This makes the initial syllable the only tolerable location for a unary foot. Starting from Biangai, further reranking IAMB over TROCH derives the Weri pattern of right-to-left iambs. The positional FTBIN variants make it possible to capture all of the attested iterative binary exhaustive parse stress systems.

In the preceding section, it was shown that a set of constraints that are no more complex than conjunctions of negative literals can achieve broad typological coverage of attested stress patterns. No reference to a higher level of logical complexity is needed. Around 90% of the languages in Gordon (2002)'s typology were accounted for in this way, with the focus on the "core cases" of single stress and iterative binary stress systems. All attested patterns of these two types are part of the typology of the constraint set. The following section focus on the *unattested* patterns predicted to be

[2]So while this account of stress lacks a PARSE constraint, there must still be some property of the constraints in the constraint set that enables a full parse – otherwise languages like Murinbata would not emerge.

part of natural language typology – particularly why they are predicted to exist and the theoretical consequences of their existence.

4 Typological Predictions

Above it was shown that a set of markedness constraints defined as conjunctions of negative literals can capture a range of stress patterns constituting 90% of the languages in Gordon (2002)'s typology. But these patterns are not the complete typology of the set of constraints adopted here. What else is predicted? Of the total 60 predicted languages, 13 are attested. That leaves 47 languages in the typology generated by permutation of constraints in the constraint set that are unattested. It will be seen that despite the limitation of the constraint definition language to CNLs, pathological overgeneration still occurs. The overgeneration has a theme: many unattested patterns show an extreme sensitivity to word length when it comes to placement of stress. In cases where there is only minor variation, this means – for example – a language that displays initial stress except in a single form of a certain length. In the more implausible, pathological cases, this means extreme variation depending on whether the word contains an even number of syllables or and odd number of syllables. Stress assignment should hold to a general pattern in words of all lengths, but this is not reflected in this typology. This section examines the unattested languages in detail[3] – how they arise, similarities to attested patterns, and whether or not they are plausible as natural language stress patterns.[4]

4.1 Single-stress variants

The attested single stress patterns are initial stress, peninitial stress, antepenultimate stress, penultimate stress, and final stress. All five patterns are found in the typology. In addition to these, fourteen other single stress languages are predicted to exist by the set of constraints.

This subgroup of stress patterns contains both plausible and implausible patterns. Among the patterns deemed plausible is a group of lan-

[3]See the Appendix for detailed information and rankings on all languages

[4]It is noted that "plausibility" relies heavily on the intuition of the observer, may be subject to bias, and is difficult to characterize formally.

guages that closely mirror attested single stress patterns, but with minor variation at a certain word length. There are seven such languages in the typology. Consider, for example, language 14 in the Appendix of single stress. This language shows initial stress in all forms except for the trisyllabic form, where there is penultimate stress instead.

(19) single-stress language 14
(ˈσσ)
σ(ˈσσ)
(ˈσσ)σσ
(ˈσσ)σσσ
(ˈσσ)σσσσ
(ˈσσ)σσσσσ

This a minor variation of the attested initial stress pattern that, while apparently unattested, is not implausible. It is important to understand how this pattern arises, and so the following tableau is given:

(20) single-stress language 14

input	winner	loser	FtBinInit	FtBinMid	FtBinFin	*InitLapse	Troch	Iamb	¬Fω	¬ωF	*LL	*LLR
4syll	(ˈσσ)σσ	σσ(ˈσσ)				W			L	W	L	L
2syll	(ˈσσ)	(σˈσ)					W	L				
4syll	(ˈσσ)σσ	(ˈσσ)(ˈσσ)						W	L		L	L
3syll	σ(ˈσσ)	(ˈσσ)σ							W	L		
4syll	(ˈσσ)σσ	σ(ˈσσ)σ								W	L	L

Comparing this with the tableau for initial stress above in (9), the only difference is that ¬ω*F* has been demoted below ¬*F*ω in the variant language, bifurcating what was the lowest stratum in the true initial stress ranking into two separate strata. This alteration to the ranking allows the variant language to emerge – while *InitialLapse can still encourage left-edge foot placement in a way similar to ¬ω*F*, as in the first winner-loser pair, it crucially cannot choose between candidates in the trisyllabic form. Both σ(ˈσσ) and (ˈσσ)σ equally satisfy *INITIALLAPSE. The decision then falls to ¬*F*ω which, now ranked above ¬ω*F*, chooses σ(ˈσσ) as the winner. ¬ω*F* is not, however, inactive. In the final winner-loser pair, it prefers initial-stress (ˈσσ)σσ over σ(ˈσσ)σ, as ¬*F*ω is ambivalent and ¬ω*F* outranks *LONGLAPSE and *LONGLAPSERIGHT, which the loser better satisfies.

The typology of single stress systems contains several examples of such languages, where reranking of a lone constraint allows a minor variation of an attested single stress pattern to emerge, typically differing in stress placement in just one form.

Another interesting case involves languages that mirror an attested single-stress pattern in terms of desired stress placement, but do so with the opposite foot type than would be expected. Take peninitial stress, for example. Peninitial stress involves placement of an iamb on the left edge of a word, as shown above in (10). However, language 12 of the typology of single-stress systems appears to be a peninitial stress language with trochees.

(21) single-stress language 12
(ˈσσ)
σ(ˈσσ)
σ(ˈσσ)σ
σ(ˈσσ)σσ
σ(ˈσσ)σσσ
σ(ˈσσ)σσσσ

Other than the two-syllable form, where the demand for trochees prevents peninitial stress, the language shows a trochaic, peninitial pattern. There are two languages of this category in the typology. The following tableau shows how this pattern arises:

(22) single-stress language 12

input	winner	loser	FtBinInit	FtBinMid	FtBinFin	*InitLapse	Troch	Iamb	¬Fω	*LL	*LLR	¬ωF
5syll	σ(ˈσσ)σσ	σσσ(ˈσσ)				W			L		L	
5syll	σ(ˈσσ)σσ	σσ(ˈσσ)σ				W				L	L	
2syll	(ˈσσ)	(σˈσ)					W	L				
5syll	σ(ˈσσ)σσ	σ(ˈσσ)(ˈσσ)						W	L	L	L	
3syll	σ(ˈσσ)	(ˈσσ)σ							W			L
5syll	σ(ˈσσ)σσ	(ˈσσ)σσσ								W		L

Looking at the tableau in (22) alongside the tableau for peninitial stress in (10), there are two changes. The relative ranking of the foot form constraints Troch and Iamb have changed so that Troch now outranks Iamb. Given the change in foot type, this is to be expected. In addition to this, ¬ω*F* has been demoted to the very bottom of the hierarchy. This is similar to the the alteration that allowed the initial-stress variant described above to emerge. *InitialLapse is active here as well – in the first two winner-loser pairs, it motivates placement of the trochee despite the preference for the loser by ¬*F*ω and the other lapse constraints. Troch outranking Iamb makes (ˈσσ) inevitable as the disyllabic form. In the trisyllabic form, ¬*F*ω, now outranking ¬ω*F*, rules in favor of a right-aligned trochee, just as in (20). In the final winner-loser pair, high-ranked *InitialLapse is equally satisfied by both candidates. The decision falls to *LongLapse, as having stress in the peninitial position means fewer long lapses (one in the winner vs. two in the loser). This is also the direct result of the demotion of ¬ω*F*, which would prefer the loser. These factors coalesce to produce a trochaic pseudo-peninitial stress pattern. It is assumed to be plausible on the basis that locating stress on the peninitial syllable is a requirement that attested languages are known to make.

While there are similarities between this variation and the initial-stress variation discussed above, there is another point to be made. This language and the ranking that generates it demonstrate a property of this set of constraints – they can motivate placement of stress in certain positions regardless of requirements on foot type. The existence of both true peninitial stress and this trochaic variant make the point clear. Whether the language uses trochees or iambs, this set of constraints can set the target for stress placement in the same position, producing two languages that differ only in foot type (and in disyllables where there is no choice)[5]. A first glance suggests that the lapse-type constraints are responsible – they can require stress to appear in certain places regardless of foot form, as just seen in (22) where *INITIALLAPSE held the trochee in place despite the desire of *LONGLAPSE and *LONGLAPSERIGHT to pull the stress away from the left edge. The role of the lapse constraints in producing these micro-variant languages will be discussed further below.

Among the languages of the single-stress typology, there is a group of languages that target one location for stress in words of shorter lengths, and a different location in longer words. Language 7 in Table 1 of the appendix is an example:

(23) single-stress language 7
(σˈσ)
(σˈσ)σ
(σˈσ)σσ
σσσ(σˈσ)
σσσσ(σˈσ)
σσσσσ(σˈσ)

This "flip" pattern, where the foot switches edges as the word grows longer, is unattested and strikingly unnatural. If single-stress languages aim to fix stress in a desired location, then this location should not change drastically as the length of the word changes. What causes it to change? The following tableau shows how this pattern arises:

[5]Note, however, that this ambiguity is an aspect of learning feet. Feet are pieces of hidden structure – they have no overt acoustic realization. As such, a learner is free to entertain an iambic or trochaic hypothesis for their language until incontrovertible evidence one way or the other is encountered. See Tesar (2004) for more on learning with structural ambiguity

(24) single-stress language 7

input	winner	loser	FtBinInit	FtBinMid	FtBinFin	*LLR	Iamb	Troch	¬ωF	*InitLapse	¬Fω	*LL
5syll	σσσ(σˈσ)	(σˈσ)σσσ				W			L	L	W	L
2syll	(σˈσ)	(ˈσσ)					W	L				
5syll	σσσ(σˈσ)	(σˈσ)(σˈσ)σ						W	L	L	W	L
3syll	(σˈσ)σ	σ(σˈσ)							W	W	L	
5syll	σσσ(σˈσ)	σ(σˈσ)σσ									W	L

It is useful to compare this with the ranking for true peninitial stress seen in (10). Single-stress language 7 has demoted *InitialLapse and ¬ω*F* to a lower stratum, and has promoted *LongLapseRight to the highest stratum. This arrangement allows the pattern to emerge. In four-syllable or shorter forms, having an iamb on the left edge does not induce a violation of *LongLapseRight, and so lower ranked ¬ω*F* and *InitialLapse prefer the foot to be placed there. At a length of five syllables or more, however, a left-aligned iamb would cause violations of *LongLapseRight, and so the higher-ranked constraint demands that the foot be placed elsewhere. There are a few possible locations for the foot that satisfy *LongLapseRight, but the last winner-loser pair in the tableau shows that ¬*F*ω has the final say, ensuring that the "flip" of the foot is complete in that it lands flush with the right edge, despite incurring violations of *LongLapse.

As with the other stress variants discussed above, demotion of ¬ω*F* or ¬*F*ω below a lapse constraint allows the unusual pattern to emerge. But this is not the whole story – the lapse constraints seen here are a subset of the lapse constraints in Gordon (2002), and yet these single-stress variants are absent from Gordon's typology. The difference is in the constraints ¬ω*F* and ¬*F*ω, absent from Gordon's constraint set.[6] While ¬ω*F* and ¬*F*ω are in a lower stratum in these cases, they are not inactive. It is this combination of a high-ranked lapse constraint and active lower-ranked ¬ω*F* and ¬*F*ω that allows for the emergence of these unusual patterns. Whereas the unattested patterns discussed above are plausible, single-stress language

[6] Remember that Gordon (2002) uses Align-type constraints

7 is not. Though it is part of the predicted typology of the constraint set, the extreme change in stress location triggered by word length is highly unnatural. Four such patterns are present in the typology of single-stress. The discussion now turns to variations on binary stress patterns.

4.2 Binary-stress variants

The attested binary stress patterns build multiple iambs or trochees from the left or right edge of the word, choosing either to allow unary feet and exhaustively parse all syllables or to ban unary feet and leave some syllables unparsed. All eight possible combinations of directionality, parse level, and foot type are found in the typology of the constraint set adopted here, though only seven are attested. In addition to these, twenty-nine other unattested patterns are present.

Among the unattested languages are plausible patterns that are not known to exist. One such pattern builds iambs from right to left non-exhaustively, leaving a lapse at the beginning of odd-parity forms – language 4 in Table 2 of the appendix. Though it is unattested, it is taken to be plausible based on the existence of all of its left-to-right/trochaic/full parse counterparts. Starting from the ranking of Pintupi in (14), swapping the location of $\neg\omega F$ and $\neg F\omega$ as well as the location of TROCH and IAMB leads to the generation of binary stress language 4. As it is generated by constraints that are also indispensable in accounting for core attested patterns, language 4 is taken to be a plausible but as of yet unseen language of the world – not an impossibility.

Another plausible pattern in the typology that is unknown in natural language involves switching of foot type to satisfy *INITIALLAPSE. Language 28 in the typology of binary stress is an interesting mirror of a "non-finality" language. Non-finality languages avoid stressing the final syllable by changing foot type from iambs to trochees for the final foot only. Southern Paiute (Harms 1966) is an example. Language 28, however, changes the foot type of the *initial* foot from iamb to trochee to avoid creation of an initial lapse.

(25) binary stress language 28
(σˈσ)
σ(ˈσσ)
(σˈσ)(σˈσ)
σ(ˈσσ)(σˈσ)
(σˈσ)(σˈσ)(σˈσ)
σ(ˈσσ)(σˈσ)(σˈσ)

The default foot type of the language is iambs, but when building iambs from right to left would create an initial lapse, the leftmost foot is a trochee instead. The following tableau shows how this is achieved:

(26) binary stress language 28

input	winner	loser	¬Fω	FtBinInit	FtBinMid	FtBinFin	*InitLapse	*LL	*LLR	¬ωF	Iamb	Troch
3syll	σ(ˈσσ)	(σˈσ)σ	W							L	L	W
3syll	σ(ˈσσ)	(ˈσ)(σˈσ)		W						L		W
5syll	σ(ˈσσ)(σˈσ)	(σˈσ) (ˈσ)(σˈσ)			W					L		W
3syll	σ(ˈσσ)	(σˈσ)(ˈσ)				W				L		W
3syll	σ(ˈσσ)	σ(σˈσ)					W				L	W
2syll	(σˈσ)	(ˈσσ)									W	L

As ¬*F*ω dominates ¬ω*F*, alignment will be on the right edge. Any attempts to create unary feet as a way to avoid initial lapse are banned by the various FtBin constraints. The effect of *InitialLapse is seen in the last trisyllabic winner-loser pair. An attempt to right-align an iamb in this case creates an initial lapse, and thus fails, even though lower-ranked Iamb would prefer the loser. This ranking generates binary stress language 28, a kind of mirror image of a non-finality pattern that changes foot type to place stress in a word-initial window.

Houghton (2013, chap. 3) states that switch languages are an inevitability of a Con that contains a rhythm constraint (such as *InitLapse), a parsing constraint (such as the FtBin variants), and an alignment constraint (such as ¬ω*F* or ¬*F*ω) – something that is borne out here. Houghton also predicts the existence of the language in (25) with *LAPSE, FTBIN, and a constraint FINALFOOT that serves the role of $\neg F\omega$ here by enforcing right-alignment[7]. Houghton (2013, p.132) states that: "since the constraints which produce switching are necessary constraints elsewhere in phonology, switch languages are an entailed consequence of the theory". In terms of plausibility, if languages like Southern Paiute that switch foot type to avoid final stress exist, then a language that does so to avoid initial lapse could exist as well.

A less plausible type of stress pattern found in the typology of binary stress involves a drastic change in foot placement from the six-syllable form to the seven-syllable form. Four languages exhibit this type of pattern. Language 25 is an example.

(27) binary stress language 25
(σˈσ)
(σˈσ)σ
(σˈσ)(σˈσ)
(σˈσ)(σˈσ)σ
(σˈσ)(σˈσ)(σˈσ)
(σˈσ)σσσ(σˈσ)

Up to the six-syllable form, the language builds iambs from left to right non-exhaustively. This is the pattern of Araucanian, mentioned above in the discussion of Pintupi. However, in the seven-syllable form, two iambs are suddenly thrown to the edges of the word, with a string of unparsed syllables in between. This is unusual and implausible for similar reasons that single-stress language 7, shown above in (23) and (24) is implausible – the way a language assigns stress should not change so starkly based on word length. A language that builds iambs from left to right up to the six-syllable form should not then alter its stress pattern in longer forms. The following tableau shows how this pattern emerges:

[7]Houghton (2013, chap. 2, §1) also predicts the existence of other right-edge oriented switch languages that are absent from this typology because the CON adopted here does not contain a plain *LAPSE constraint. While *INITIALLAPSE can act like *LAPSE at the left edge, it cannot do so at the right edge, and so languages that switch foot type to avoid a two-syllable lapse at the right edge are not predicted to exist in this theory of stress.

(28) binary stress language 25

input	winner	loser	FtBinInit	FtBinMid	FtBinFin	*InitLapse	*LLR	Iamb	¬Fω	Troch	¬ωF	*LL
3syll	(σˈσ)σ	σ(σˈσ)				W			L		W	
5syll	(σˈσ)(σˈσ)σ	(σˈσ)σσσ					W			L		W
3syll	(σˈσ)σ	σ(ˈσσ)						W	L	L	W	
4syll	(σˈσ)(σˈσ)	(σˈσ)σσ							W	L		
7syll	(σˈσ)σσσ(σˈσ)	(σˈσ)(σˈσ)(σˈσ)σ								W	L	L

¬ω*F* is in the lowest stratum, and so it is *InitialLapse together with Iamb that places the foot on the left edge in trisyllabic forms, despite ¬*F*ω's preference for right alignment. In the five-syllable form, *LongLapseRight motivates the placement of an additional foot to break up the lapse present in the loser, even though doing so further violates Troch. In the four-syllable form, it is not *LongLapseRight that requires placement of another foot, but ¬*F*ω. The winner and loser perform equally well with regards to *LongLapseRight, but creating another foot means no unparsed syllable between the right edge and rightmost foot, better satisfying ¬*F*ω at the cost of further Troch violations. Finally, in the seven-syllable form, Troch limits the number of iambs created to two. High-ranking *InitialLapse and *LongLapseRight must be satisfied, and one way to do this while also minimally violating Troch is to place an iamb on each edge.

This pattern is unattested and strikingly unnatural. Stress assignment should show some uniformity across words of all lengths – the process should not alter as word length changes. But such languages are predicted to exist here – in this case highly-ranked constraints that ban lapses at edges combined with the foot antagonistic nature of Troch allows the pattern to emerge. This kind of overgeneration is absent from Gordon (2002)'s typology, and the reason is clear – Gordon's theory of stress does not refer to feet. The foot antagonism of the Troch and Iamb constraints plays an important role in generating languages such as binary stress language 25, but these constraints are not part of Gordon's theory of stress, and so such languages are not predicted to exist. Other approaches using feet may also suffer from these problems, though it is not entirely clear.

In Kager (2012), a unary foot violates IAMB but not TROCHEE, because: "different assumptions regarding foot type result(ed) in larger typologies, but not to better matches with the typology" (p. 1474). This is a hint that the way the foot form constraints are defined here is problematic, and that a different definition would reduce some of the pathological overgeneration.

Another bad prediction made by the set of constraints involves ambiguous languages. These languages show a plausible parse up to the six-syllable form, but the seven-syllable form is ambiguous with regards to the placement of an internal unary foot – two outputs emerge as equally optimal. There are nine such languages in the typology. Language 13 is an example.

(29) binary stress language 13
(σˈσ)
(σˈσ)(ˈσ)
(σˈσ)(σˈσ)
(σˈσ)(ˈσ)(σˈσ)
(σˈσ)(σˈσ)(σˈσ)
(σˈσ)(ˈσ)(σˈσ)(σˈσ) / (σˈσ)(σˈσ)(ˈσ)(σˈσ)

Up to the four syllable form, the language mirrors Ojibwa, with a left-to-right exhaustive iambic parse. But then, in the five syllable form, the unary foot is in the middle of the word. Finally, the seven-syllable is ambiguous – either placement for the unary foot is equally optimal. This is the defining quality of the ambiguous languages – they want to keep the unary foot off the edges, but cannot decide between word-medial positions for it. The following tableau shows how this situation arises:

(30) binary stress language 13

input	winner	loser	¬ωF	¬Fω	FtBinInit	*InitLapse	*LL	*LLR	FtBinFin	Iamb	FtBinMid	Troch
3syll	(σˈσ)(ˈσ)	σ(ˈσσ)	W						L			L
3syll	(σˈσ)(ˈσ)	σ(σˈσ)	W			W			L	L		L
3syll	(σˈσ)(ˈσ)	(σˈσ)σ		W					L	L		L
3syll	(σˈσ)(ˈσ)	(ˈσ)(σˈσ)			W				L			
5syll	(σˈσ)(ˈσ)(σˈσ)	(σˈσ)(σˈσ)(ˈσ)							W		L	
2syll	(σˈσ)	(ˈσσ)								W		L

As seen in the discussion of exhaustive binary stress above, ¬ω*F* and ¬*F*ω conspire to ensure a full parse. FtBinInitial, ranked in the highest stratum and above the other FtBin constraints, ensures that the unary foot is word-final in the trisyllabic form. In the five syllable form FtBinFinal prefers the winner, with the unary foot in the middle of the word. FtBinMid is outranked by both other FtBin constraints, meaning that the unary foot will float away from the word edges. This is what causes the ambiguity in the seven-syllable form – having the unary foot in either word-internal position equally satisfies FtBinInitial and FtBinFinal and equally violates FtBinMid, and there is no other constraint in the constraint set that can differentiate the two ambiguous forms.

Predicting languages with ambiguous forms is undesirable, and it is a direct result of the division of FtBin into the three position-sensitive parts. As Gordon (2002) makes no reference to feet, this sort of ambiguity is absent from the typology seen there. The division of FtBin leads to some good predictions with regards to attested binary exhaustive languages, correctly placing the unary foot in languages such as Murinbata in (18). But by introducing the ability to independently rank the positional FtBin variants, languages that prefer to place the unary foot in the middle of the word are predicted, with no “failsafe” – no other constraint in the constraint set that can distinguish different word-internal positions. Adding some other constraint may do away with the ambiguity, but it is not clear what *local* – successor only – constraint could achieve this. Failure to differentiate these forms may result from this theory’s inability to refer to distant positions in a non-local way. Constraints banning a unary foot preceding/proceeding the word edge and a foot (¬ # (ˈσσ)(ˈσ) and/or

¬ (ˈσ)(ˈσσ) #) may work for a seven-syllable word, but would fail as the word grew longer and more internal positions appeared.[8] Adding any constraint will also change the typology predicted by the constraint set in ways that are difficult to predict. Further consideration of this problem is left for a later date.

Another chunk of the binary stress language typology is comprised of unattested languages that iterate stress less fully than their attested counterparts. Some languages mirror attested patterns but have one less foot in certain forms. Others are more extreme variations. Fifteen languages exhibit such patterns. An example of the former is language 22. This language is similar to Araucanian, but has less full parsing. The two patterns are shown below.

(31)

binary stress language 22	Araucanian
(σˈσ)	(σˈσ)
(σˈσ)σ	(σˈσ)σ
(σˈσ)σσ	(σˈσ)(σˈσ)
(σˈσ)(σˈσ)σ	(σˈσ)(σˈσ)σ
(σˈσ)(σˈσ)σσ	(σˈσ)(σˈσ)(σˈσ)
(σˈσ)(σˈσ)(σˈσ)σ	(σˈσ)(σˈσ)(σˈσ)σ

Language 22 exhibits a left-to-right non-exhaustive iambic parse, like Araucanian, but the final pair of syllables is left unfooted in even-syllable forms longer than two. The difference in constraint ranking that allows for this variation is minor. The hierarchies of both languages are provided here for ease of reference, with the relevant constraints in bold:

(32) Araucanian
$\neg\omega F$, FtBinFin, FtBinMid, FtBinInit, *LL, *LLR, *InitLapse, Iamb » $\neg F\omega$ » **Troch**

binary stress language 22
$\neg\omega F$, FtBinFin, FtBinMid, FtBinInit, *LL, *LLR, *InitLapse, Iamb » **Troch** » $\neg F\omega$

The two languages are identical except for the lowest strata – in Araucanian $\neg F\omega$ outranks Troch, but in language 22 Troch outranks $\neg F\omega$.

[8] See McCarthy (2003, p.79-80) for more discussion on why this approach is unsatisfactory.

This is the crucial difference. When ¬*F*ω outranks TROCH, the foot antagonism of TROCH is suppressed, and a fuller parse is preferred, allowing (σˈσ)(σˈσ) to surface instead of (σˈσ)σσ. This is the Araucanian case. When TROCH outranks ¬*F*ω, the foot antagonistic nature of TROCH prevents the creation of additional iambs, even though this would better satisfy ¬*F*ω, preferring (σˈσ)σσ and (σˈσ)(σˈσ)σσ to their full-parse counterparts. The higher-ranked *LONGLAPSE and *LONGLAPSERIGHT must be satisfied, however, and so iambs are added minimally to avoid long lapses. This is binary stress language 22.

Foot antagonism is an important component of theories of stress that employ feet, and as language 22 is a "more foot-antagonistic" variant of Araucanian, it is taken to be a plausible stress pattern. Gordon (2002)'s account of stress does not refer to feet, and so these types of patterns are absent from the typology seen there. For other theories of stress that do refer to feet, if an antagonistic foot-type constraint can be ranked above a constraint that promotes creation of feet, and there are also highly-ranked *LONGLAPSE-type constraints, then this sort of "minimal foot creation to avoid long lapse" pattern is likely to emerge.

Also in this group of languages are less-plausible unattested patterns that are not just slight variations on attested patterns. An example is binary stress language 30.

(33) binary stress language 30
(ˈσσ)
σ(ˈσσ)
σ(ˈσσ)σ
σσ(ˈσσ)σ
σ(ˈσσ)(ˈσσ)σ
σ(ˈσσ)σ(ˈσσ)σ

This language, like others above, shows some variation in how stress is assigned depending on the length of the word. It is not clear that it is a mirror or slight variant of any attested pattern. The language avoids long lapses at all costs, but is tolerant of an initial lapse – as in the five-syllable form – when preventing the initial lapse would mean creating another trochee. The following tableau shows how this pattern arises.

(34) binary stress language 30

input	winner	loser	FtBinInit	FtBinMid	FtBinFin	*LL	*LLR	Troch	Iamb	*InitLapse	¬Fω	¬ωF
6syll	σ(ˈσσ)(ˈσσ)σ	σσσσ(ˈσσ)				W			L	W	L	
2syll	(ˈσσ)	(σˈσ)						W	L			
5syll	σσ(ˈσσ)σ	σ(ˈσσ)(ˈσσ)							W	L	L	
4syll	σ(ˈσσ)σ	σσ(ˈσσ)								W	L	
3syll	σ(ˈσσ)	(ˈσσ)σ									W	L

With ¬*F*ω and ¬ω*F* in the lowest strata, it is the lapse constraints that motivate foot placement in this language. In the first winner-loser pair, the candidate with an additional trochee better satisfies *LongLapse, despite incurring further violations of Iamb. In the five-syllable form, however, foot-antagonistic Iamb successfully prevents the creation of another trochee, as the higher-ranked lapse constraints are satisfied by both the winner and loser. In the four-syllable form, *InitialLapse is obeyed, moving the foot off the right edge despite ¬*F*ω's preference for the loser. In the trisyllabic form, where any placement of stress satisfies all lapse constraints, ¬*F*ω is allowed to enforce right alignment of the lone foot.

When the antagonist foot type constraint (Iamb in this case) occupies a stratum of its own directly below its counterpart, creation of additional feet beyond the first only occurs in order to satisfy the higher-ranked lapse constraints. In attested patterns such as Pintupi and Araucanian, the opposite foot-form constraint is relegated to the lowest stratum, and exerts no foot-antagonistic force. The attested and unattested but plausible patterns also show a sense of directionality as a result of ranking ¬*F*ω or ¬ω*F* in the top stratum. There is a sense of building in one direction starting from some edge that is not as clear in languages like language 30.

This drive to place stress in a way that avoids lapses can operate independently of the foot type. To drive this home, compare the patterns of binary stress language 30 with that of binary stress language 20, given here side by side for ease of comparison:

(35)	binary stress language 30	binary stress language 20
	(ˈσσ)	(σˈσ)
	σ(ˈσσ)	(σˈσ)σ
	σ(ˈσσ)σ	(σˈσ)σσ
	σσ(ˈσσ)σ	σ(σˈσ)σσ
	σ(ˈσσ)(ˈσσ)σ	(σˈσ)(σˈσ)σσ
	σ(ˈσσ)σ(ˈσσ)σ	(σˈσ)σ(σˈσ)σσ

Other than the disyllabic form, where there is no choice but to obey the higher-ranked foot type constraint, these two languages assign stress to the same locations despite the fact that one employs trochees and one employs iambs. These iamb-trochee counterparts emerge as the result of the lapse constraints present in the constraint set, which only care about distance between stresses and edges, not foot type. This kind of pattern is taken to be implausible due to its unclear directionality and the inconsistency in stress assignment between words of different lengths. While several of these languages resemble what Gordon (2002) terms "ternarity plus binarity" patterns, there are no languages of exactly the type in (35) found in the typology of that theory of stress. As Gordon does not refer to feet, the iamb-trochee mirrors are absent as well.

This subsection examined the unattested binary stress patterns present in the typology. While both plausible and implausible patterns are represented, a theme emerged – the interaction of the lapse constraints and the foot-antagonistic TROCH and IAMB underpins much of the overgeneration. This also provides an explanation for the divergence in Gordon (2002)'s typology and the typology examined here – with no feet in his account of stress, the interactions with lapse constraints do not happen, and so these unattested languages are not generated.

4.3 Sour grapes-style foot building

This subsection examines a group of four languages in the typology that exhibit a kind of "sour grapes" pattern. Sour grapes phenomena have been identified in the realm of harmony and spreading (Padgett 1995; Wilson 2003, 2006; McCarthy 2010) and tone phenomenon (Jardine 2016). In sour grapes spreading, if some feature can not spread over the entire word, then the candidate with no spreading at all is selected as optimal instead. This involves the interaction of a markedness and faithfulness constraint – the markedness constraint (AGREE or ALIGN) requiring agreement on some feature in adjacent segments, and the faithfulness constraint IDENTIO(F) penalizing input-output changes in the relevant feature.

Here, however, there is a sour grapes stress pattern that arises from a constraint set containing *only* markedness constraints limited to the computational complexity of conjunctions of negative literals – no faithfulness constraints are present. That the constraints are limited to CNL-logic is especially noteworthy here because these sour grapes patterns are provably non-star-free – they are at least fully regular[9]. Regular patterns are those describable with a regular expression or finite-state automaton (FSA). In terms of logical complexity, regular patterns are at the level of Monadic Second-Order Logic (MSO), higher than CNLs and higher than even the First-Order or Propositional Logic seen above in (3). The process of optimization over candidates in OT can generate patterns of much higher logical complexity than the constraints themselves. The pattern of sour grapes language 1 is given here:

(36) sour grapes language 1
(ˈσσ)
(ˈσσ)σ
(ˈσσ)(ˈσσ)
(ˈσσ)σσσ
(ˈσσ)(ˈσσ)(ˈσσ)
(ˈσσ)σσσσσ

The language starts with a normal right-to-left trochaic parse up to the four-syllable form, but then in the five syllable form the pattern breaks – only one foot is created. The six-syllable form returns to a full parse of syllables to feet, but the seven-syllable form again only builds one foot. This is the "sour grapes" pattern – the language wants to build binary feet all the way to the end of the word. If this cannot be done, as in odd-numbered-syllable forms, then the bare minimum is done instead – only one foot is created.[10] No further feet are "spread" to the right. The following tableau shows how this is pattern arises:

[9] See Appendix for proof

[10] In other sour grapes phenomena, the "bare minimum" is not done – no spreading occurs *at all* in nasal-spreading sour grapes processes with blocking, for instance. In

(37) sour grapes language 1

input	winner	loser	¬ωF	FtBinInit	FtBinMid	FtBinFin	*InitLapse	Troch	¬Fω	Iamb	*LL	*LLR
3syll	(ˈσσ)σ	σ(ˈσσ)	W						L			
3syll	(ˈσσ)σ	(ˈσ)(σˈσ)		W				W	L			
5syll	(ˈσσ)σσσ	(σˈσ)(ˈσ)(σˈσ)			W			W	L		L	L
3syll	(ˈσσ)σ	(σˈσ)(ˈσ)				W		W	L			
2syll	(ˈσσ)	(σˈσ)						W		L		
4syll	(ˈσσ)(ˈσσ)	(ˈσσ)σσ							W	L	W	W
5syll	(ˈσσ)σσσ	(ˈσσ)(ˈσσ)σ								W	L	L

Having ¬ω*F* in the top stratum gives the language its left-to-right orientation. The FtBin constraints prevent the creation of any unary feet – only binary feet can be built. The four-syllable winner-loser pair is revealing – a binary foot is added, as it fully parses all syllables and satisfies ¬*F*ω. For this sour grapes pattern, ¬*F*ω is the spreading constraint – instead of spreading a feature or a tone, it looks to "spread" the parse by bringing all syllables into feet. The next winner-loser pair shows us how this fails in odd-parity forms: if maximal creation of binary feet does not fully satisfy ¬*F*ω, then foot-antagonist Iamb prevents the creation of additional trochees. Spreading of the parse is blocked.

This pattern is pathological and arises from the interaction of markedness constraints only – no faithfulness constraints. Gordon (2002)'s typology contains no such patterns. An important part of what allows this language to appear in the typology is the presence of the pseudo-alignment constraints ¬*F*ω and ¬ω*F*. These constraints encourage the spread of feet because they are most satisfied when every syllable is parsed to a foot. This proved crucial in the analysis of exhaustive-parse binary systems like Murinbata in (18), but their role in generating sour grapes patterns raises questions. ¬*F*ω and ¬ω*F* were posited and defined as CNLs in the hopes of avoiding issues that have been identified with the more complex Align-schematic constraints. But if these CNL constraints, when fed through the optimization process in OT, can generate pathological patterns of much

theories of stress that assume culminativity, however, this is not an option – at least one stress, and therefore one foot, must be present.

higher complexity, then the "simple constraint" enterprise is called into question. It is possible that more powerful constraints are needed to constraint overgeneration in stress typology – Gordon (2002) employs ALIGN-type constraints but predicts no sour grapes patterns. Learnability may also play a role – Stanton (2016) suggests that the Midpoint Pathology may not be seen in natural language because the pattern is difficult to learn – the main idea being that learnability shapes typology. Whatever the case, the ability of strictly local CNL constraints to produce non-local, regular patterns is a noteworthy result.

5 Discussion

To evaluate the theory of stress presented in this paper, Gordon (2002) was used as a benchmark. While this was useful for establishing a base of attested patterns as targets for typological coverage, it is difficult to compare the two systems directly. For one, I commit to a CDL that uses CNL logic, and all constraints are limited to that level of expressive power. Gordon makes no explicit claim about a CDL, and uses more complex constraints such as ALIGN. Secondly, the metrical theory of this paper makes reference to feet, while Gordon eschews feet and instead marks stress on a metrical grid. While the two systems agree on the attested patterns, it is exactly these differences that result in the divergence between the two stress typologies – the foot type constraints and other CNL constraints cause the gross overgeneration discussed in §4. Gordon also overgenerates, but in a different direction, predicting a range of unattested ternary patterns absent from the typology presented here.

The overgeneration of the system leads to some interesting questions. Do other OT stress systems that employ foot form constraints like IAMB and TROCH make similarly bad typological predictions? That Kager (2012) adjusts the definition of the two constrains in an explicitly articulated effort to constrain overgeneration suggests that yes, having foot type constraints defined as they are here may be problematic. The challenge then is in making the correct adjustment. What *exactly* is it about the foot type constraints that leads to problems, and how can they be changed in a way that is not just an *ad hoc* patch thrown on to skirt around known issues?

Another line for future research could be wholesale abandonment of feet. If foot type constraints are problematic, then a metrical grid approach like in Gordon (2002) could produce interesting results. What is the typology of CNL constraints on a metrical grid? Applying the same methodology seen here to these questions will produce a factorial typology of CNL stress that makes no reference to feet. Then the task would be to compare that typology with the one generated here. Does one system capture more attested patterns while also predicting fewer pathological patterns? If there is a clear winner in this regard then it may give us a hint as to how stress should be represented in phonology in general.

A CDL limited to CNL logic appears to be too weak. The prediction of nine ambiguous languages was analyzed above as a failure of SL constraints to distinguish between different internal positions within a word. Proposing local constraints that *can* distinguish for words of a certain length by including a nearby word edge in their definition then fail for longer words as more internal positions appear. There appears to be no unified local-constraint solution to the problem without expanding the system presented here.

One solution is to find something local enough to refer to. This is the approach of Kager (2005), who proposes the constraint LAPSE-IN-TROUGH to pick apart forms like (ˈσσ)σ(ˌσσ)(ˌσσ) and (ˈσσ)(ˌσσ)σ(ˌσσ) by banning a lapse between two secondary stress syllables – ¬ˌσσσˌσ if defined as a CNL. Including a constraint like this here would entail making reference to levels of stress, which would undoubtedly alter the predicted typology significantly.

Another option is to break from the limitation to CNLs that only use successor. Instead of being limited to the successor relation, including the precedence relation may have interesting results. Formally, adding precedence brings us from SL to strictly piecewise (SP) (Heinz 2010). This move does not, however, increase the logical complexity of the CDL proposed for markedness constraints in this paper – SP patterns are still definable with CNL logic. So, including precedence allows for reference to distant positions within a word, but still keeps the constraints very simple. The ability to reference a distant position would obviate the need for local constraints that grow arbitrarily long as the word grows longer. It is also in line with Hyde (2012)'s claim that distance sensitivity is a necessary component of stress theories. Including precedence ensures changes of both unattested and attested patterns in the typology. What predictions does a strictly piecewise system make? This line of investigation is left for future work.

While this theory of stress produces a typology with a number of unnatural patterns, they are not all created equal. An important distinction must be drawn. In patterns like those in (32) and (33), we have the intuition that this variation with regards to word length is unnatural. This is an intuition that extends to the sour grapes patterns as well – but there is a key difference. The sour grapes patterns have a formal characterization that explains exactly *why* they seem so odd – they are provably regular, a level of complexity that far exceeds the constraints that produced them. This also puts sour grapes stress at the threshold of what has been proposed as the complexity limit for phonology in general (Heinz 2015). On the other hand, patterns like those in (32) and (33) have *no* formal characterization for their unnaturalness – no unifying or defining factor other than the intuition of phonologists. Whether a formal characterization for these patterns can be formulated as well is left for later research.

The sour grapes result shows that strictly local patterns are not closed under OT optimization – a set of strictly local OT constraints can generate non-local patterns. This is in line with results for constraints as regular relations seen in Frank and Satta (1998) and Gerdemann and Hulden (2012), and calls the drive to simplify constraints into question. As mentioned above, Gordon (2002) employs the FOL ALIGN constraints in his analysis of stress, but predicts no sour grapes patterns. Establishing a CDL for constraints and having explicit definitions will always be important for a complete OT. But if optimization over candidates with CNL constraints can generate a factorial typology with pathological regular patterns, then it is unclear what stands to be gained by proposing a CDL that is maximally simple. It is possible that more powerful logics for the CDL are needed to constrain pathological overgeneration. This issue remains open for now.

6 Conclusion

This paper investigated a theory of stress with a constraint definition language for markedness constraints limited to the logical complexity of conjunctions of negative literals. The goal was to show that a set of strictly local, categorical constraints are sufficient to capture a core subset – 90% – of the quantity insensitive patterns seen in the typology of Gordon (2002).

The chosen subset of languages are generated by the constraints in the constraint set, but unattested patterns in the typology prove to be the most informative. A theme emerged – extreme sensitivity to word length for assignment of stress. If stress languages aim to have stress in a certain location, then this location should not change as the word grows longer or shorter. This kind of variation is a direct result of the interaction of the constraints in the constraint set. With the correct arrangement of constraints, stress can vary from words of one length to another in a way that seems unnatural.

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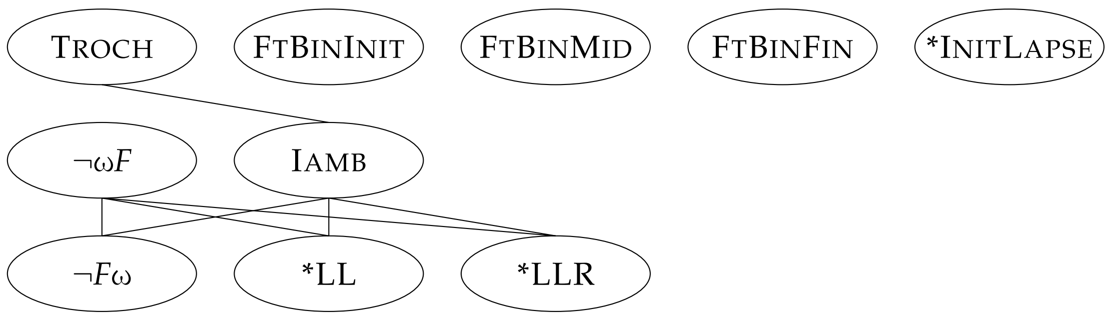
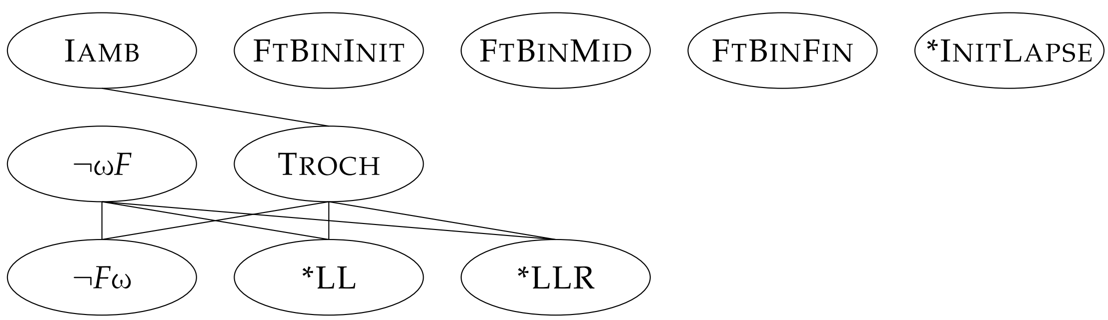
Appendix

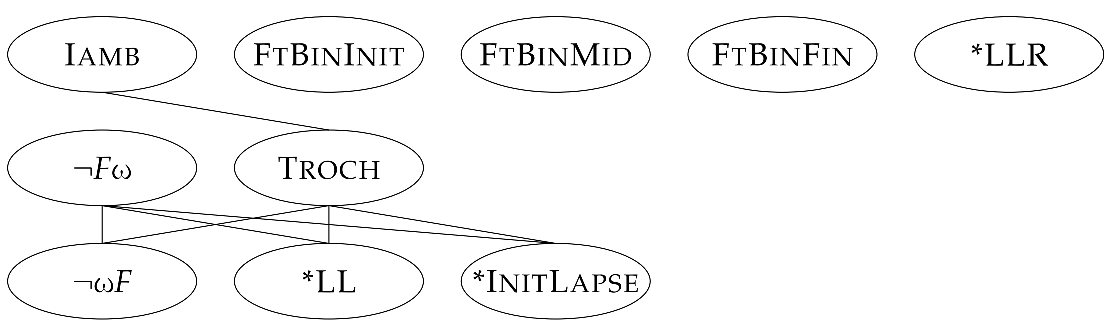
initial stress



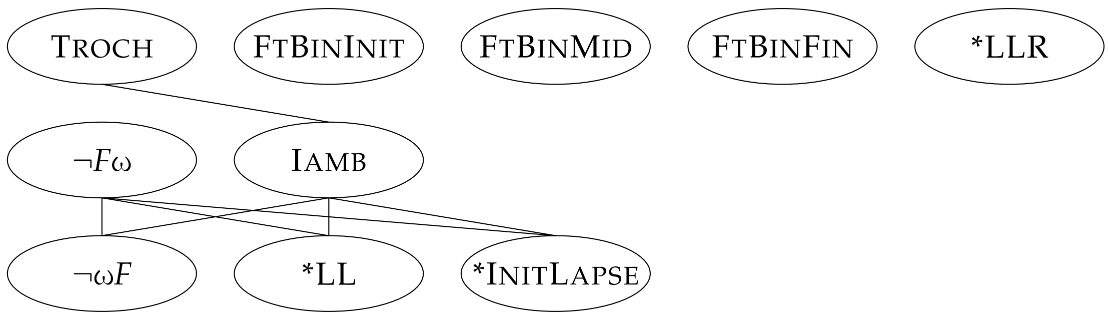
peninitial stress



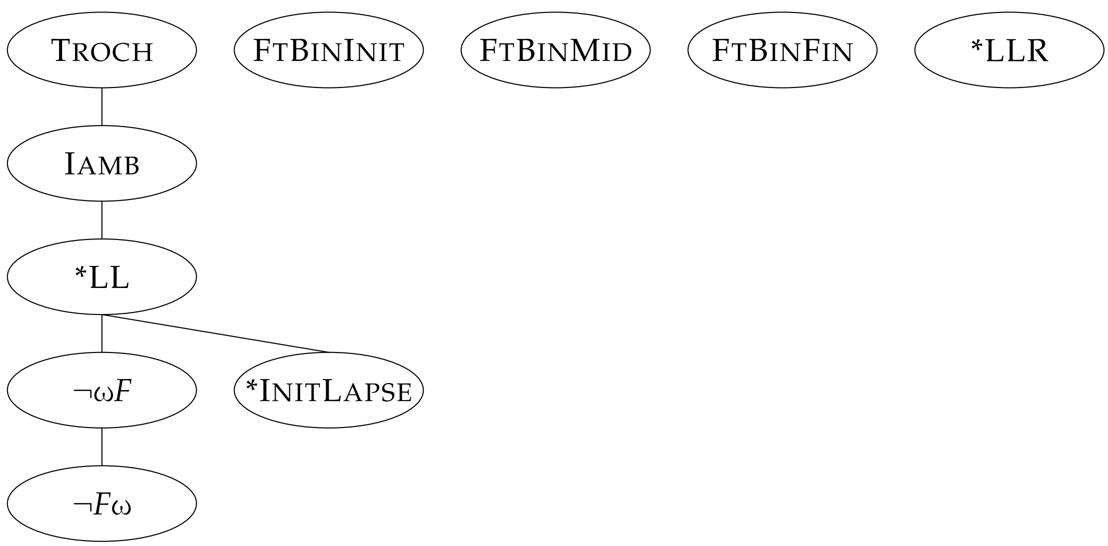
final stress



penultimate stress



antepenultimate stress



Sour grapes stress is not star-free

Proving that the sour grapes pattern in (36) is not star-free will prove that it is regular. In order to do so, it is necessary to reference the following theorem:

> (Rogers and Pullum 2011b) *A language L is star-free iff it is non-counting, that is, iff there exists some $n > 0$ such that for all strings u,v,w over Σ, if uv^nw occurs in L then $uv^{n+i}w$, for all $i \geq 1$, occurs in L as well.*

Since this principle must hold for **all** i ≥ 1 at some (any) $n > 0$, proving that sour grapes is not SF is a matter of finding two classes of counter-examples to this theorem—one for any odd n and one for any even n. Doing so shows that substituting any even or odd number for n (so, any integer) will also fail to meet the requirements of the theorem. This will prove that the sour grapes-like pattern seen here is fully regular, and that SL patterns are not closed under optimization.

Taking (36) to be our L, I point out an important property of the language. No string $(\sigma\sigma)\sigma^n$ for an even value of n will appear in the language—even-syllable forms always parse all syllables to feet. Using $(\sigma\sigma)\sigma^n$ with even n as the target for the $uv^{n+i}w$ part of Theorem 1, the following proof can be formulated:

Theorem 2: The pattern of L is not SF.

Proof: Let uv^1w be the string $(\sigma\sigma)\sigma\sigma\sigma \in L$ such that u = $(\sigma\sigma)$, v^1 = σ, and w = $\sigma\sigma$. Set i to 1. For any odd value of n, $|v^nw|$ will be an odd-number string of syllables, and $|v^{n+1}w|$ will be an even-number string of syllables, meaning the string $uv^{n+1}w$ will also be even. For example, if $n = 1$, u = $(\sigma\sigma)$, v^2 = $\sigma\sigma$, and w = $\sigma\sigma$. The string uv^2w over Σ is $(\sigma\sigma)\sigma\sigma\sigma\sigma$ and $(\sigma\sigma)\sigma\sigma\sigma\sigma \notin L$. Thus L fails Thm. 1 for any odd n.

Let uv^2w be the string $(\sigma\sigma)\sigma\sigma\sigma \in L$ such that u = $(\sigma\sigma)$, v^2 = $\sigma\sigma$, and w = σ. Set i to 1. For any even value of n, $|v^nw|$ will be an even-number string of syllables, and $|v^{n+1}w|$ will be an odd-number string of syllables, meaning the string $uv^{n+1}w$ will also be odd. For example, if $n = 2$, u = $(\sigma\sigma)$, v^3 = $\sigma\sigma\sigma$, and w = σ. The string uv^3w over Σ is $(\sigma\sigma)\sigma\sigma\sigma\sigma$ and $(\sigma\sigma)\sigma\sigma\sigma\sigma \notin L$. Thus L also fails Thm. 1 for any even n.

This demonstration that for any odd n and even n, if $uv^{\mathrm{n}}w$ is a string of L then $uv^{\mathrm{n+i}}w$ is not a string of L proves that Thm. 1 does not hold for the sour grapes-style pattern. It proves that this pattern is not SF and is properly regular.

Table 1: Typology of single stress

1.	Initial: Nenets	¬ω*F*, *INITLAPSE, TROCH » IAMB » ¬*F*ω, *LL, *LLR
2.	Peninitial: Lakota	¬ω*F*, *INITLAPSE, IAMB » TROCH » ¬*F*ω, *LL, *LLR
3.	Antepenultimate: Macedonian	*LLR, TROCH » IAMB » ¬ω*F*, *INITLAPSE, *LL » ¬*F*ω
4.	Penultimate: Albanian	¬*F*ω, *LLR, TROCH » IAMB » ¬ω*F*, *LL, *INITLAPSE
5.	Final: Atayal	¬*F*ω, *LLR, IAMB » TROCH » ¬ω*F*, *INITLAPSE, *LL
6.	Iambic Antepenultimate w/ 0(01): unattested	IAMB » TROCH » *LL » ¬*F*ω » ¬ω*F*, *INITLAPSE
7.	Peninitial/final – 1,2,3σpeninitial, 4σ+ final: unattested	*LLR, IAMB » TROCH » ¬ω*F*, *INITLAPSE » ¬*F*ω » *LL
8.	Peninitial/antepenultimate – 1,2,3σpeninitial, 4σ+ antepenultimate: unattested	*LLR, IAMB » TROCH » ¬ω*F*, *INITLAPSE, *LL » ¬*F*ω
9.	Penultimate/antepenultimate – 1,2,3σpenultimate, 4σ+ antepenultimate: unattested	TROCH, *LLR » IAMB » *LL » ¬*F*ω » ¬ω*F*, *INITLAPSE
10.	Penultimate w/ 0(10)0: unattested	¬*F*ω » IAMB » *INITLAPSE » ¬*F*ω » ¬ω*F*, *LL
11.	Antepenultimate w/ 0(10): unattested	*LLR, TROCH » IAMB » *INITLAPSE, *LL » ¬*F*ω » ¬ω*F*
12.	Trochaic peninitial w/ (10): unattested	*INITLAPSE, TROCH » IAMB » ¬*F*ω, *LL, *LLR » ¬ω*F*
13.	Initial w/ 0(10), 0(10)0: unattested	*INITLAPSE, TROCH » IAMB » ¬*F*ω, *LLR » ¬ω*F* » *LL
14.	Initial w/ 0(10): unattested	*INITLAPSE, TROCH » IAMB » ¬*F*ω » ¬ω*F* » *LL, *LLR
15.	Penultimate w/ (10)0: unattested	*LLR, TROCH » IAMB » ¬ω*F* » ¬*F*ω » *INITLAPSE, *LL
16.	Antepenultimate w/ 00(10): unattested	*LLR, TROCH » IAMB » ¬ω*F*, *LL » ¬*F*ω » *INITLAPSE
17.	Penultimate w/ (10)0, 0(10)0: unattested	*LLR, TROCH » IAMB » ¬ω*F*, *INITLAPSE » ¬*F*ω » *LL
18.	Trochaic peninitial w/ (10), (10)0: unattested	*INITLAPSE, TROCH » IAMB » *LL, *LLR » ¬ω*F* » ¬*F*ω
19.	Initial w/ 0(10)0: unattested	*INITLAPSE, TROCH » IAMB » *LLR » ¬ω*F* » ¬*F*ω, *LL

Table 2: Typology of binary stress

1.	L-to-R Trochees non-exhaustive: Pintupi (10), (10)0, (10)(10), (10)(10)0, (10)(10)(10), (10)(10)(10)0	¬ωF, FtBinFin, FtBinMid, FtBinInit, *LL, *LLR, *InitLapse, Troch » ¬Fω, Iamb
2.	R-to-L Trochees non-exhaustive: Warao (10), 0(10), (10)(10), 0(10)(10), (10)(10)(10), 0(10)(10)(10)	¬Fω, FtBinFin, FtBinMid, FtBinInit, *LL, *LLR, *InitLapse, Troch » ¬ωF, Iamb
3.	L-to-R Iambs non-exhaustive: Araucanian (01), (01)0, (01)(01), (01)(01)0, (01)(01)(01), (01)(01)(01)0	¬ωF, FtBinFin, FtBinMid, FtBinInit, *LL, *LLR, *InitLapse, Iamb » ¬Fω » Troch
4.	R-to-L Iambs non-exhaustive: unattested (01), 0(01), (01)(01), 0(01)(01), (01)(01)(01), 0(01)(01)(01)	¬Fω, FtBinFin, FtBinMid, FtBinInit, *LL, *LLR, Iamb » ¬ωF, *InitLapse, Troch
5.	L-to-R Trochees exhaustive: Murinbata (10), (10)(1), (10)(10), (10)(10)(1), (10)(10)(10), (10)(10)(10)(1)	¬ωF, ¬Fω, FtBinMid, FtBinInit, *LL, *LLR, *InitLapse » FtBinFin, Troch » Iamb
6.	R-to-L Trochees exhaustive: Biangai (10), (1)(10), (10)(10), (1)(10)(10), (10)(10)(10), (1)(10)(10)(10)	¬ωF, ¬Fω, FtBinMid, FtBinFin, *LL, *LLR, *InitLapse » FtBinInit, Troch » Iamb
7.	L-to-R Iambs exhaustive: Ojibwa (01), (01)(1), (01)(01), (01)(01)(1), (01)(01)(01), (01)(01)(01)(1)	¬ωF, ¬Fω, FtBinMid, FtBinInit, *LL, *LLR, *InitLapse » FtBinFin, Iamb » Troch
8.	R-to-L Iambs exhaustive: Weri (01), (1)(01), (01)(01), (1)(01)(01), (01)(01)(01), (1)(01)(01)(01)	¬ωF, ¬Fω, FtBinMid, FtBinFin, *LL, *LLR, *InitLapse » FtBinInit, Iamb » Troch

9.	binary: unattested (01), 0(01), (01)00, 0(01)00, (01)(01)00, 0(01)(01)00	FtBinInit, FtBinMid, FtBinFin, *LL, *LLR, Iamb » Troch » ¬*F*ω » ¬ω*F*, *InitialLapse
10.	FtBinMid ambiguous: unattested (01), 0(01), (01)(01), (01)(1)(01), (01)(01)(01), (01)(1)(01)(01) / (01)(01)(1)(01)	¬*F*ω, FtBinInit, FtBinFin, *LL, *LLR » ¬ω*F* » FtBinMid, Iamb » *InitialLapse, Troch
11.	FtBinMid ambiguous: unattested (01), (01)0, (01)(01), (01)(1)(01), (01)(01)(01), (01)(1)(01)(01) / (01)(01)(1)(01)	¬ω*F*, FtBinInit, FtBinFin, *InitialLapse, *LL, *LLR » ¬*F*ω » FtBinMid, Iamb »Troch
12.	FtBinMid ambiguous: unattested (01), 0(10), (01)(01), (01)(1)(01), (01)(01)(01), (01)(1)(01)(01) / (01)(01)(1)(01)	¬*F*ω, FtBinInit, FtBinFin, *InitialLapse, *LL, *LLR » ¬ω*F*, Iamb » FtBinMid, Troch
13.	FtBinMid ambiguous: unattested (01), (01)(1), (01)(01), (01)(1)(01), (01)(01)(01), (01)(1)(01)(01) / (01)(01)(1)(01)	¬ω*F*, ¬*F*ω, FtBinInit, *InitialLapse, *LL, *LLR » FtBinFin, Iamb » FtBinMid, Troch
14.	FtBinMid ambiguous: unattested (01), (1)(01), (01)(01), (01)(1)(01), (01)(01)(01), (01)(1)(01)(01) / (01)(01)(1)(01)	¬ω*F*, ¬*F*ω, FtBinFin, *InitialLapse, *LL, *LLR » FtBinInit, Iamb » FtBinMid, Troch
15.	FtBinMid ambiguous: unattested (10), 0(10), (10)(10), (10)(1)(10), (10)(10)(10), (10)(1)(10)(10) / (10)(10)(1)(10)	¬*F*ω, FtBinInit, FtBinFin, *InitialLapse, *LL, *LLR » ¬ω*F* » FtBinMid, Troch » Iamb
16.	FtBinMid ambiguous: unattested (10), (10)0, (10)(10), (10)(1)(10), (10)(10)(10), (10)(1)(10)(10) / (10)(10)(1)(10)	¬ω*F*, FtBinInit, FtBinFin, *InitialLapse, *LL, *LLR » ¬*F*ω » FtBinMid, Troch » Iamb
17.	FtBinMid ambiguous: unattested (10), (1)(10), (10)(10), (10)(1)(10), (10)(10)(10), (10)(1)(10)(10) / (10)(10)(1)(10)	¬ω*F*, ¬*F*ω, FtBinFin, *InitialLapse, *LL, *LLR » FtBinInit, Troch » FtBinMid, Iamb
18.	FtBinMid ambiguous: unattested (10), (10)(1), (10)(10), (10)(1)(10), (10)(10)(10), (10)(1)(10)(10) / (10)(10)(1)(10)	¬ω*F*, ¬*F*ω, FtBinInit, *InitialLapse, *LL, *LLR » FtBinFin, Troch » FtBinMid, Iamb

19.	binary: unattested (01), (01)0, (01)00, 0(01)00, (01)(01)00, 0(01)(01)00	FtBinInit, FtBinMid, FtBinFin, *LL, *LLR, Iamb » Troch » ¬ω*F* » ¬*F*ω » *InitialLapse
20.	binary: unattested (01), (01)0, (01)00, 0(01)00, (01)(01)00, (01)0(01)00	FtBinInit, FtBinMid, FtBinFin, *LL, *LLR, Iamb » Troch » ¬ω*F*, *InitialLapse » ¬*F*ω
21.	binary: unattested (01), (01)0, (01)00, (01)(01)0, (01)(01)00, (01)0(01)00	FtBinInit, FtBinMid, FtBinFin, *InitialLapse, *LL, *LLR, Iamb » Troch » ¬ω*F*, ¬*F*ω
22.	binary: unattested (01), (01)0, (01)00, (01)(01)0, (01)(01)00, (01)(01)(01)0	¬ω*F*, FtBinInit, FtBinMid, FtBinFin, *InitialLapse, *LL, *LLR, Iamb » Troch » ¬*F*ω
23.	binary: unattested (10), 0(10), 00(10), 0(10)(10), 00(10)(10), 0(10)(10)(10)	¬*F*ω, FtBinInit, FtBinMid, FtBinFin, *LL, *LLR, Troch » Iamb » ¬ω*F*, *InitialLapse
24.	7σ switch binary: unattested (01), (01)0, (01)00, (01)(01)0, (01)(01)00, (01)000(01)	FtBinInit, FtBinMid, FtBinFin, *InitialLapse, *LLR, Iamb » Troch » ¬ω*F*, ¬*F*ω » *LL
25.	7σ switch binary: unattested (01), (01)0, (01)(01), (01)(01)0, (01)(01)(01), (01)000(01)	FtBinInit, FtBinMid, FtBinFin, *InitialLapse, *LLR, Iamb » ¬*F*ω » Troch » ¬ω*F*, *LL
26.	7σ switch binary: unattested (10), 0(10), 0(10)0, 0(10)(10), 0(10)(10)0, (10)000(10)	FtBinInit, FtBinMid, FtBinFin, *InitialLapse, *LLR, Troch » Iamb » ¬*F*ω » ¬ω*F* » *LL
27.	7σ switch binary: unattested (10), (10)0, 0(10)0, (10)(10)0, 0(10)(10)0, (10)000(10)	FtBinInit, FtBinMid, FtBinFin, *InitialLapse, *LLR, Troch » Iamb » ¬ω*F* » ¬*F*ω » *LL
28.	Ft type switch: unattested (01), 0(10), (01)(01), 0(10)(01), (01)(01)(01), 0(10)(01)(01)	¬*F*ω, FtBinInit, FtBinMid, FtBinFin, *InitialLapse, *LL, *LLR » ¬ω*F*, Iamb » Troch

29.	binary: unattested (10), 0(10), 00(10), 00(10)0, 00(10)(10), 00(10)(10)0	FTBININIT, FTBINMID, FTBINFIN, *LL, *LLR, TROCH » IAMB » ¬*F*ω » ¬ω*F*, *INITIALLAPSE
30.	binary: unattested (10), 0(10), 0(10)0, 00(10)0, 0(10)(10)0, 0(10)0(10)0	FTBININIT, FTBINMID, FTBINFIN, *LL, *LLR, TROCH » IAMB » *INITIALLAPSE » ¬*F*ω » ¬ω*F*
31.	binary: unattested (10), 0(10), 0(10)0, 0(10)(10), 0(10)(10)0, 0(10)00(10)	FTBININIT, FTBINMID, FTBINFIN, *INITIALLAPSE, *LLR, TROCH » IAMB » ¬*F*ω » *LL » ¬ω*F*
32.	binary: unattested (10), 0(10), 0(10)0, 0(10)(10), 0(10)(10)0, 0(10)0(10)0	FTBININIT, FTBINMID, FTBINFIN, *INITIALLAPSE, *LL, *LLR, TROCH » IAMB » ¬*F*ω » ¬ω*F*
33.	binary: unattested (10), (10)0, 00(10), 00(10)0, 00(10)(10), 00(10)(10)0	FTBININIT, FTBINMID, FTBINFIN, *LL, *LLR, TROCH » IAMB » ¬ω*F* » ¬*F*ω » *INITIALLAPSE
34.	binary: unattested (10), (10)0, 0(10)0, 00(10)0, 0(10)(10)0, 00(10)(10)0	FTBININIT, FTBINMID, FTBINFIN, *LL, *LLR, TROCH » IAMB » ¬ω*F* » *INITIALLAPSE » ¬*F*ω
35.	binary: unattested (10), (10)0, 0(10)0, 00(10)0, 0(10)(10)0, 0(10)0(10)0	FTBININIT, FTBINMID, FTBINFIN, *LL, *LLR, TROCH » IAMB » *INITIALLAPSE » ¬ω*F* » ¬*F*ω
36.	binary: unattested (10), (10)0, 0(10)0, (10)(10)0, 0(10)(10)0, 0(10)0(10)0	FTBININIT, FTBINMID, FTBINFIN, *INITIALLAPSE, *LL, *LLR, TROCH » IAMB » ¬ω*F* » ¬*F*ω
37.	binary: unattested (10), (10)0, 0(10)0, (10)(10)0, 0(10)(10)0, (10)00(10)0	FTBININIT, FTBINMID, FTBINFIN, *INITIALLAPSE, *LLR, TROCH » IAMB » ¬ω*F* » *LL » ¬*F*ω

Table 3: Typology of sour grapes patterns

1.	sour grapes R iambs: unattested (01), 0(01), (01)(01), 000(01), (01)(01)(01), 00000(01)	¬Fω, FtBinInit, FtBinMid, FtBinFin, *LLR, Iamb » ¬ωF, *InitialLapse » Troch » *LL
2.	sour grapes, L iambs: unattested (01), (01)0, (01)(01), (01)000, (01)(01)(01), (01)00000	¬ωF, FtBinInit, FtBinMid, FtBinFin, *InitialLapse, Iamb » ¬Fω » Troch » *LL, *LLR
3.	sour grapes, L trochees: unattested (10), (10)0, (10)(10), (10)000, (10)(10)(10), (10)00000	¬ωF, FtBinInit, FtBinMid, FtBinFin, *InitialLapse, Troch » ¬Fω » Iamb » *LL, *LLR
4.	sour grapes, R trochees: unattested (10), 0(10), (10)(10), 000(10), (10)(10)(10), 00000(10)	¬Fω, FtBinInit, FtBinMid, FtBinFin, *LLR, Troch » ¬ωF » Iamb » *InitialLapse, *LL