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► **To cite this version:**

Ben Hermans, Francesc Torres-Tamarit. Onset weight with branchingness constraints: The case of Piraha. 2015 Annual Meeting on Phonology, Oct 2015, Vancouver, Canada. hal-01593575

HAL Id: hal-01593575

<https://hal.science/hal-01593575>

Submitted on 9 Jan 2018

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Onset Weight with Branchingness Constraints: The Case of Pirahã

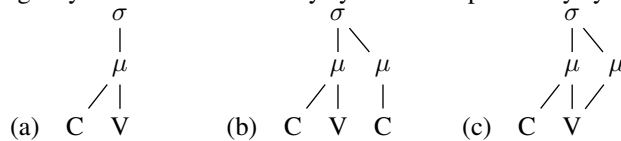
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1 Introduction

In Moraic Theory (Hyman 1985, Hayes 1989, 1995), the weight of a syllable is expressed in terms of the number of moras. The more moras a syllable has, the heavier it is. Thus, a syllable with just one mora is light—it never attracts stress, whereas a syllable with two moras does attract stress in some languages. This distinction is illustrated in (1).

(1) Light syllable *vs.* closed heavy syllable *vs.* open heavy syllable

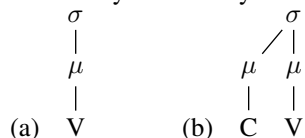


It is clear from the representations in (1) that a segment in onset position cannot contribute to a syllable's weight; no matter how many consonants are present in the onset, and no matter what kind of consonant is located in the onset, the structure of the onset cannot have any bearing on the location of stress. This is true irrespective of whether we assume that onsets are syllabified under the first mora (following Hyman 1985), or whether we follow Hayes (1989) and say that onsets are adjoined to the syllable node and are not dominated by a mora at all.

In Everett and Everett (1984), however, the authors show quite convincingly that this prediction is not borne out; in Pirahã a syllable with a voiceless onset is heavier than a syllable without an onset, provided the number of moras of both syllable types is identical.

This observation has led Topintzi (2006) to propose that in those languages where onsets do contribute to weight, onsets create a mora. We thus get representations like those in (2).

(2) Onsetless syllable *vs.* syllable with a moraic onset



Assigning moraic status to onset consonants of course explains that onsets do sometimes contribute to weight, but it goes at a cost. It is well known that moras favor relatively sonorous segments (*cf.* Blevins 1995 and Zec 2007 for overviews). If the hypothesis that moras tend to be relatively sonorous is combined with the proposal that onsets do sometimes create a mora, then it is predicted that moraic onset consonants should tend to be sonorous. This however is quite incorrect. In those languages where onset consonants are moraic it is the case that relatively less sonorous consonants are located in the moraic onset, whereas the relatively sonorous consonants tend to avoid the moraic onset. The facts are exactly the opposite of what we expect.

On these grounds we reject the moraic theory of onset weight, and propose an entirely different proposal. In fact we return to the oldest theories of weight sensitivity and claim that dependent positions (prosodically weak positions) tend to avoid branching constituents, whereas head positions (prosodically strong positions)

* We thank the audience of the Annual Meeting on Phonology 2015 in Vancouver for helpful feedback on this work.

tend to attract branching constituents (Hayes 1980, Hammond 1986). This approach does not suffer from the problem created by the moraic approach towards onset weight.

In the next section we present the facts of Pirahã, one of the most complex cases of quantity sensitivity, in which onset weight also plays a role. In the third section we sketch our approach based on branchingness. We conclude in the fourth section.

2 Weight sensitivity in Pirahã

Pirahã has five degrees of weight. Syllables with long vowels are heavier than syllables with short vowels. Among the syllables with the same number of moras, the syllables with an onset are heavier than the syllables without an onset. Furthermore, among the syllables with the same number of moras and an onset, the syllables with a voiceless onset are heavier than the syllables with a voiced onset. These five degrees can be schematized as in (3).

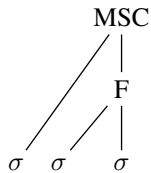
- (3) Pirahã weight scale (Hayes 1995:286, Topintzi 2006:56)
 $PVV > BVV > VV > PV > BV > V$
 (where P = voiceless consonant; B = voiced obstruent; VV = long vowel)

The stress rule of Pirahã runs as follows: within a window of three syllables at the right word edge, the heaviest syllable is stressed, where heaviness is defined in terms of the scale in (3). If all three syllables in the window are equally heavy, then the rightmost syllable is stressed. This is illustrated with the examples in (4), taken from Topintzi (2006:57). We have not indicated tone as it does not determine the distribution of stress.

- (4) Stress in Pirahã
- | | |
|-------------------------------|-----------------|
| (a) $PVV > BVV$ | (b) $BVV > VV$ |
| 'kao.ba.bai | 'bii.oa.ii |
| pa.'hai.bii | poo.'gai.hi.ai |
| 'pii.bi.gai | |
| (c) $VV > PV$ | (d) $PV > BV$ |
| pia.hao.gi.so.'ai.pi | 'ʔa.ba.gi |
| | ti.'po.gi |
| (e) Rightmost heaviest stress | |
| ʔa.ba.'pa | city name |
| ho.ao.'ii | 'shotgun' |
| ti.'po.gi | species of bird |
| pao.hoa.'hai | 'anaconda' |

First of all, we must establish what the formal status of a three-syllable window is. We assume that main stress is represented by a foot dominated by a main stress constituent (Hermans and Torres-Tamarit 2014, *cf.* Martínez-Paricio and Kager 2015). Both constituent types are maximally binary (they can only have two daughters). Due to this maximality constraint, the maximal MSC (main stress constituent) contains at most three syllables. This is shown in (5), where the MSC and the foot are right headed. Headedness is represented with straight lines, and dependency is indicated with slanted lines. Thus, in the representation in (5) the first two syllables are dependents, and the final syllable is the head.

- (5) Window and stress



If the MSC would contain more than three syllables, then the maximality constraint would be violated, either at the foot level, or at the MSC-level and neither is allowed.

In Pirahã stress gravitates to the right if all three syllables (within the three-syllable window) are equally heavy. This suggests that in Pirahã the foot and the MSC are right headed in the unmarked case. We express this with the constraints in (6).

(6) Constraints on stress placement

a. Ft-RIGHTHEADEDNESS

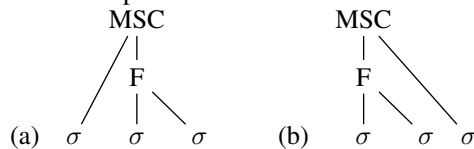
The head of a foot is located at the right.

b. MSC-RIGHTHEADEDNESS

The head of a MSC is located at the right.

A metrical structure of the type given in (5) is not penalized by the two constraints in (6), which accounts for the fact that this is the unmarked type of constituent in Pirahã. This is not to say that other structures are completely excluded in this language. Indeed, circumstances might arise where structures like those in (7) emerge as optimal, as we will see.

(7) Marked but possible metrical structures



In Pirahã the main stress constituent is assigned at the right edge of the word. This is expressed with the alignment constraint in (8), which is undominated in the language (*cf.* Hyde 2012 on the formalism of alignment constraints).

(8) MSC-Right

The right edge of the MSC is aligned with the right word edge.

So far we have seen that Pirahã has a three-syllable window at the right word edge. The two constituents making up the window are right headed, entailing that stress is final if all syllables in the three-syllable window are equally heavy.

How can we explain that the stress is retracted from the rightmost syllable to the heaviest syllable in the three-syllable window? Let us, for the time being, work with an informal constraint, called HEAVY, which says that the heavier a syllable is, the worse it is in a dependent position in a MSC. In the next section we will see what exactly this constraint formally means. Consider a form like 'kao.ba.bai. Given the weight scale in (3), the first syllable is the heaviest in the three-syllable window, and it is therefore stressed, retracting stress from the final (default) position, all the way to the antepenult syllable. Retraction to the left, induced by a syllable's weight, implies that our informal constraint HEAVY must be ranked with respect to a variety of other constraints. First of all it must dominate the two RIGHTHEADEDNESS constraints, as we show in the tableau in (9) (in this tableau we have lumped together Ft-RIGHTHEADEDNESS and MSC-RIGHTHEADEDNESS). In this tableau a syllable of the structure PVV is assigned two violations of HEAVY (if it is located in a dependent position) and a syllable of the structure BVV is assigned one violation of HEAVY (if that syllable is located in a dependent position). This is done to make explicit that PVV is heavier than BVV, according to the weight scale. The inner brackets in the candidates are the foot boundaries and the outer brackets are the MSC boundaries.

(9) Tableau for 'kao.ba.bai

kaobabai	HEAVY	RIGHTHEADEDNESS
a. [kʰao.ba]bai	*	**
b. (kao[ba.'bai])	**!	

In the first candidate the heaviest syllable in the three-syllable window is stressed, violating RIGHTHEADEDNESS twice (at foot level and at the MSC-level), but violating HEAVY only once, due to the fact that a syllable of the structure BVV is located in a dependent position. In the second candidate HEAVY is violated twice, since it has a PVV syllable in a dependent position, but RIGHTHEADEDNESS is satisfied. Since in Pirahã HEAVY dominates RIGHTHEADEDNESS, the first candidate is optimal.

There is an obvious alternative candidate which does not violate HEAVY at all, and also satisfies RIGHTHEADEDNESS. This is the candidate in which the MSC is smaller than three syllables. This candidate is included in the tableau in (10).

(10) Tableau for 'kao.ba.bai II

kaobabai	HEAVY	RIGHTHEADEDNESS
a. ☹ ('kao.ba)bai)	*	**
b. (kao(ba.'bai))	**!	
c. ☞ kao((ba.'bai))		

The tableau shows that the third candidate is wrongly predicted to be the optimal candidate under the constraints considered so far: the dependent contains the lightest syllable of the weight scale, so that the candidate does not violate HEAVY at all; furthermore, RIGHTHEADEDNESS is not violated at all, because in the third candidate there is no left headed constituent. Why then is the third candidate not optimal? Obviously, the window is not maximal in the third candidate; it is just bisyllabic. It is therefore a violation of the family of constraints PARSE. The constraint of this family that is relevant to us is formulated in (11).

(11) PARSE- σ /MSC

A syllable must be dominated by the MSC.

This constraint penalizes a syllable that is excluded from the MSC, as happens with the first syllable in the third candidate in (10). To obtain the correct results, we have to rank PARSE- σ /MSC over HEAVY, as we show in the tableau in (12).

(12) Tableau for 'kao.ba.bai III

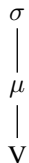
kaobabai	PARSE- σ /MSC	HEAVY	RIGHTHEADEDNESS
a. ☞ ('kao.ba)bai)		*	**
b. (kao(ba.'bai))		**!	
c. kao((ba.'bai))	*!		

In the next section we will propose a new approach to onset weight, one that is based on branchingness conditions. There we will be precise about the formal content of the informal constraint we have so far called HEAVY.

3 Heaviness based on branching

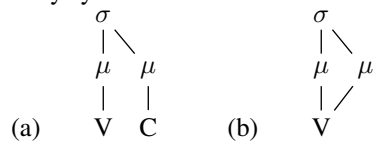
Let us first consider the general structure of a syllable. Most phonologists agree that a syllable node (σ) dominates a mora (μ), which dominates a segmental root node, either C (consonantal root node) or V (vocalic root node) (13).

(13) Basic structure of a syllable



Some phonologists (in particular de Lacy 2002, 2006) suggest that the mora is the head of the syllable. A syllable with two moras either has a long vowel or a postvocalic consonant, as shown in (14).

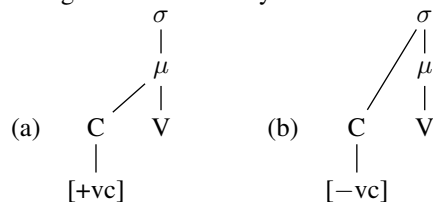
(14) Heavy syllables



We have already seen that a syllable of the general structure in (13) is a light syllable, in the sense that it does never attract stress. On the other hand, the syllable types given in (14) are heavy. How can we account for the light *vs.* heavy distinction? It seems that we just have to count the number of branching nodes. The light syllable in (13) does not branch, whereas the syllables in (14) do branch. But where are the onset consonants? According to Hyman (1985) they are parsed under the mora. According to Hayes (1989), however, they are adjoined to the syllable node. Here we propose that both are right, and that consonants of low sonority tend to be parsed directly under the syllable node, whereas other consonants prefer to be parsed under the mora.

Our idea is that in some languages a consonant of low sonority (for instance, a consonant that is [–voice]) is not allowed under the mora, so that it can only be parsed directly under the syllable node, making that node branching (15).

(15) Parsing of voiced C as Hyman *vs.* voiceless C as Hayes



We can account for the distinction between (15a) and (15b) with two constraints. They are formulated in (16).

(16) Constraints on onsets

a. SYLLABLEHEAD-BRANCH

The head of a syllable, a mora, must branch.

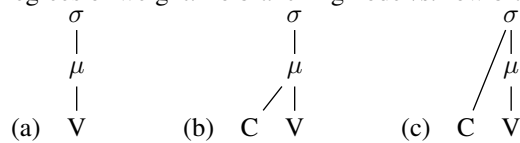
b. *[-vc]/DPT- μ

[-voice] should not be located in the dependent of a mora.

A mora is the head of a syllable, as we have seen. The constraint in (16a) thus requires that a mora that occupies the head position of a syllable should dominate two segments. Consequently, a representation like the one in (15b) is penalized by the constraint, whereas a syllable like the one in (15a) is preferred by it. The constraint in (16b), on the other hand, excludes voiceless consonants from a mora's dependent position. Exactly how a voiceless, prevocalic consonant is syllabified in a language depends on the ranking between the two constraints. If in a language SYLLABLEHEAD-BRANCH dominates *[-vc]/DPT- μ , then all consonants are parsed in a Hyman-onset. If, on the other hand, in a language *[-vc]/DPT- μ dominates SYLLABLEHEAD-BRANCH, then that language has two types of onset: a Hayes-type, where specifically voiceless consonants are located, and a Hyman-type where all other consonants are located. Needless to say that in Pirahã the latter situation obtains.

It seems, then, that not only branchingness contributes to weight; also the location of branchingness plays a role: a branching σ is heavier than a branching μ , so to speak. This is the first part of our hypothesis: a branching node adds to weight and the height of a branching node adds to weight. In principle we now have three degrees of weight among monomoraic syllables (17).

(17) Degrees of weight: no branching node *vs.* low branching node *vs.* high branching node



In (17) weight increases from left to right. Pirahã is one of the languages where [–voice] consonants are syllabified in a Hayes-onset, whereas other consonants are syllabified in a Hyman-onset. This explains why syllables with a voiceless consonant in onset position contribute more to weight than syllables with any other consonant in onset position (provided the number of moras is identical).

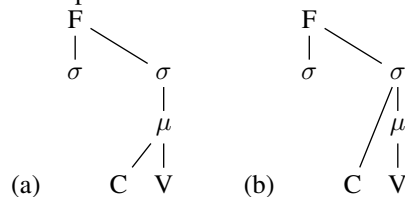
However, how does the structure of the syllable interfere with foot structure? Let us introduce the two constraints in (18).

(18) Constraints on dependents

- a. FT-HIGHDPT-NONBRANCH
The highest dependent of a foot should not branch.
- b. FT-DPT-NONBRANCH
A dependent of a foot should not branch.

To understand these two constraints, consider the representations in (19).

(19) Foot dependent structures

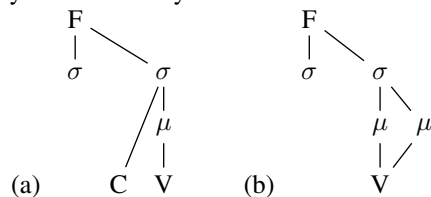


In (19) the two syllable types we are now discussing are put in a dependent position of a trochaic foot. In (19a) a syllable with a Hyman-onset is occupying the foot's dependent position, and in (19b) a syllable with a Hayes-onset is put in the foot's dependent position. The syllable node, of course, is the highest dependent of the foot, and the mora is a lower dependent of the foot. Let us now look at the effects of the two constraints in (18). They are equivalent of the traditional WEIGHT-TO-STRESS constraints, that are familiar from OT (*cf.* Kager 1999, for an overview).

The two constraints are in a stringency relation (de Lacy 2002, 2006); if the specific constraint is violated, the general one is also violated, but the reverse does not hold. Accordingly, (19a) only violates the constraint in (18b), the general constraint. The representation in (19b), however, violates both constraints, the general one and the specific one. It is the highest dependent, the syllable node, that violates both constraints. From this it follows that if there is a distinction between a syllable with a Hyman-onset and a Hayes-onset, it will always be the case, in all languages, that the syllable with a Hayes-onset counts as heavier than a syllable with a Hyman-onset. It is a consequence of the fact that the two constraints in (18) are in a stringency relation, so that a branching σ node is penalized twice, whereas a branching μ node is penalized just once.

Returning now to the (informal) weight scale of Pirahã, we can ask how to account for the fact that VV is necessarily heavier than PV. Let us consider the representations in (20).

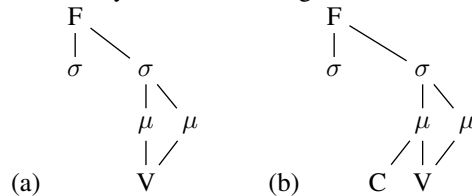
(20) Syllable with Hayes-onset *vs.* onsetless syllable with a long vowel



The representation in (20b) violates the very general constraint FT-DPT-NONBRANCH in (18b) twice, because there are two foot's dependents that branch, that is, a branching syllable and a branching V node—note that V root nodes also count as dependents, and it also violates the less general constraint in (18a) once, which prohibits the highest foot's dependent to branch, the branching syllable. The representation in (20a), however, violates the less general constraint once, which implies that it also violates the more general constraint once because of the branching syllable. It therefore follows that if in some language there is a weight distinction between bimoraic and monomoraic syllables, then it will always be the case that bimoraic syllables are heavier than monomoraic syllables, even if these monomoraic syllables have a Hayes-onset.

Let us now look at the next relation of the weight scale. Can we explain that BVV is necessarily heavier than VV (if a language makes that distinction)? Consider the representations in (21).

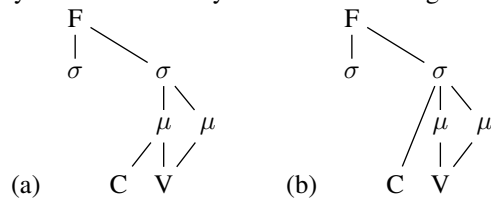
- (21) Onsetless syllable with a long vowel vs. onset syllable with a long vowel



As we have just seen, the representation in (21a) violates the two constraints we have seen so far: it violates twice FT-DPT-NONBRANCH and it violates FT-HIGHDPT-NONBRANCH once. Interestingly, (21b) fares even worse; the branching mora node that parses the onset is also a dependent, albeit not a high dependent. Therefore, the constraint FT-DPT-NONBRANCH, the very general constraint in (18), is violated three times: once at the syllable level and twice at the level of the dependent mora. This accounts for the fact that if a language makes a distinction between VV and BVV, the latter one is always heavier than the former.

Let us finally see whether we can explain that PVV is necessarily heavier than BVV, at least in a language that makes a distinction between them. Consider the representations in (22).

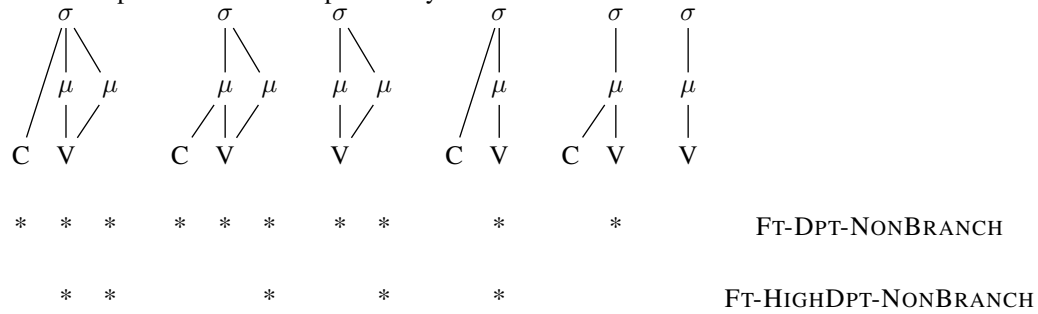
- (22) Hyman-onset vs. Hayes-onset with a long vowel



How is a node with three daughters calculated? We assume that a branchingness constraint evaluates each pair of daughters individually. Thus, in a syllable with the three daughters $\{C, \mu, \mu\}$, each pair $\{C, \mu\}$ and $\{\mu, \mu\}$ is taken into consideration by a branchingness constraint. We already know that (22a) yields three violations of the general constraint FT-DPT-NONBRANCH and one violation of FT-HIGHDPT-NONBRANCH because of the branching syllable node. In the representation in (22b), however, the syllable node violates the most specific constraint FT-HIGHDPT-NONBRANCH twice because the syllable node has three daughters. All in all, then, the dependent syllable in (22b) creates no less than five violations of the branchingness constraints. In other words, PVV is the heaviest syllable, in the sense that it dislikes its status as a foot's dependent to the highest possible degree.

We repeat these results in (23). It is an overview of our discussion in this section, showing that the various positions on the weight scale map onto a distinct number of violation marks. A syllable is heavier to the extent that it has more violation marks.

(23) Violation profiles of foot's dependent syllables



Our approach can account for all the weight degrees of Pirahã in terms of two branchingness constraints, which are the equivalent of WEIGHT-TO-STRESS, and one constraint that enforces parsing of [–voice] consonants in a Hayes-onset. The general idea is that a syllable is more harmonic outside a foot's dependent position to the extent that it violates the two constraints that are in a stringency relation.

These two constraints are the formal equivalent of the informal constraint we have labeled HEAVY in the preceding section. Both constraints, therefore, have to outrank the two RIGHTHEADEDNESS constraints and have to be dominated by the constraint PARSE-σ/MSC, as we have already shown in the tableau in (12). The tableau in (24) replaces HEAVY by the two constraints that account for the fine grained weight distinctions of Pirahã, which we label as FT-DEPT1, the more general constraint, and FT-DEPT2, the more specific constraint, for reasons of space. The comma separates the violations incurred by the two unstressed syllables, and the semicolon separates the violations assigned by the two constraints.

(24) Tableau for 'kao.ba.bai IV

kaobabai	PARSE-σ/MSC	FT-DPT1;FT-DEPT2	RIGHTHEADEDNESS
a. $\text{ka}^{\text{H}}\text{.ba}^{\text{H}}\text{.bai}$ ('kao.ba)bai)		*,***,*	**
b. (kao(ba.'bai))		***,*;***!	
c. (kao('ba.bai))		***,*;***!*,**,*	*
d. kao((ba.'bai))	*!	*	

The last candidate is rather good in terms of weight relations. In fact it only has one violation mark, created by the second syllable. This is a BV-syllable, and a syllable of this type has a lowly positioned branching dependent, a Hyman-onset; it branches at the mora level. However, the last candidate violates the higher-ranked constraint PARSE-σ/MSC, and it is therefore thrown out of the competition before the weight constraints have a chance to make a selection among candidates. Among the remaining candidates the third one is very bad indeed with respect to weight constraints. As a PVV-syllable, the first syllable creates no less than five violations: three violations are created by FT-DEPT1, which refers to FT-DEPT-NONBRANCH, and two by FT-DEPT2, which refers to FT-HIGHDEPT-NONBRANCH. Furthermore, the final syllable creates four violations: three are created by FT-DEPT1, and one is created by FT-DEPT2. The second candidate is much better with respect to the weight constraints: again the first syllable creates five violations, just like the first syllable in the third candidate. However, its second syllable only creates one violation, which is much better than the third syllable of the third candidate. Still better, though, is the first candidate. Its second syllable creates only one violation mark, and the third syllable creates four violation marks. All in all, the first candidate is slightly better than the second candidate, at least with respect to the weight constraints. It might be worse with respect to RIGHTHEADEDNESS, but that is irrelevant because RIGHTHEADEDNESS is dominated by the weight constraints. The first candidate in (24), therefore, is the optimal candidate.

4 Conclusion

So far nobody has paid much attention to the question where to parse prevocalic consonants. We claim that if a language makes a distinction between PV-syllables and BV-syllables, it will always be the case that consonants of lower sonority prefer the Hayes-onset instead of the Hyman-onset. Based on this, we have shown that it is possible to account for the highly complex quantity sensitive system of Pirahã without moraic onsets. Instead of moraic onsets we rely on two constraints against branching dependents, FT-DEPT-NONBRANCH and FT-HIGHDEP-NONBRANCH, which are in a stringency relation. In Pirahã they interact with another constraint which excludes consonants of low sonority (*in casu* [–voice] consonants) from a Hyman-onset, so that they must be parsed into a Hayes-onset, which introduces more violations of FT-HIGHDEP-NONBRANCH because the syllable node has three daughters.

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