Garcia, Guilherme D. & Ryan, Kevin. 2026. Sonority-driven stress: Codas in Brazilian Portuguese. *Glossa: a journal of general linguistics* 11(1). pp. 1–31.
DOI: https://doi.org/10.16995/glossa.25891

Open Library of Humanities

Sonority-driven stress: Codas in Brazilian Portuguese

Guilherme D. Garcia, Université Laval; CRBLM, guilherme.garcia@lli.ulaval.ca

Kevin Ryan, Harvard University, kevinryan@fas.harvard.edu

This study provides experimental evidence for sonority-driven stress in Brazilian Portuguese (BP). We show that speakers systematically prefer final stress when the ultima contains a sonorant coda {N, l, r} rather than the obstruent coda {s}. The effect is specific to the ultima, the position where weight is otherwise most relevant to BP stress. A lexical analysis of monomorphemic words corroborates the experimental pattern: /s/-final words receive final stress less often than sonorant-final words. We further show that this asymmetry cannot be reduced to morphological factors (the plural suffix /-s/ is invisible to stress), nor to a sonority-free account on which final /s/ is a prosodic appendix. These findings bear on a contested question in metrical phonology (whether, and how, segmental sonority conditions stress placement), on which experimental evidence has so far been scarce.

Glossa: a journal of general linguistics is a peer-reviewed open access journal published by the Open Library of Humanities. © 2026 The Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC-BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited. See http://creativecommons.org/licenses/by/4.0/. Articles published by the Open Library of Humanities may also contain other CC-licensed material, or material used or reproduced under an exception or limitation to copyright. Such material is not subject to the article's license. It is either marked with its own license, or marked that it has been reproduced with permission or under fair-use.

OPEN ACCESS

1 Introduction

Whether the sonority levels of segments can influence stress placement is debated in metrical phonology. While surveys of stress systems include several apparent cases of stress placement being determined by vowel or consonant sonority (e.g., Hayes 1995; Kenstowicz 1997; de Lacy 2004; Gordon 2006), more recent research has argued that several such cases are either misanalyzed or empirically unsupported (e.g., Shih 2016; 2018; Rasin 2018; Bowers 2019; Shih & de Lacy 2019; Faust & Ulfsbjorninn 2025), calling into question whether stress placement is ever affected (at least directly) by sonority. This debate has played out almost entirely on typological grounds — grammars and lexical patterns in existing words — with little in the way of experimental evidence (e.g., nonce probes or artificial grammars) to bear on the productivity of sonority-stress interactions (an exception being Carpenter 2010, which investigates vowel sonority).

This article contributes the first (to our knowledge) experimental study of the influence of consonant (specifically, coda) sonority on stress placement. In Brazilian Portuguese (BP), a word-final obstruent (only /s/ is possible) appears by some diagnostics to be non-moraic, unlike a word-final sonorant (rhotic, nasal, or underlying lateral realized as [w]). For one thing, among existing monomorphemes, final stress is substantially less likely with a final obstruent (vs. sonorant). Based on this and another fact (see §5.2), Nevins (2015: 311) proposes for BP that "sibilants are not sonorous enough to be moraic." Using two forced-choice non-word tasks, auditory and orthographic, we test whether native speakers of BP extend stress to novel forms in a way that mirrors the lexical asymmetry in sonority. In the ultima, we find, coda sonority has a substantial effect on stress judgments, a stronger effect even than in existing monomorphemes. (Among non-final syllables, by contrast, we find no sonority effects, but this null result is consistent with the lexical pattern, in which weight effects of any kind are largely confined to the ultima.)

BP is a useful test case in three respects. First, it is far more accessible than the languages around which the debate has so far turned (§2.1), and it is a language for which sonority has already been claimed to condition consonant moraicity. Second, its stress placement is only partly predictable, so that speakers face a genuine choice when they meet a novel word — which is precisely what a forced-choice design requires. The same design would not work for a fixed-stress language such as French.[1] Third, BP has no alternations in sonorant syllabicity, which would complicate the design in a language such as English.

BP's coda inventory, for its part, cuts both ways. On the one hand, three of the four codas are sonorants, which allows us to ask not only whether obstruents and sonorants differ, but also whether the sonorants differ among themselves (one might imagine, for instance, w > r > N).

[1] That said, artificial grammar learning experiments still work for such languages. For example, Carpenter (2010) finds that French (and English) speakers learn a natural association between vowel sonority and stress more easily than an unnatural association.

They do not: only the broad obstruent vs. sonorant division is supported, and we take the absence of finer distinctions to be an informative null. On the other hand, the obstruent side of the contrast rests on a single segment, /s/, which doubles as the plural suffix /-s/. We argue in §4.1 that the sonority finding is not an artifact of final /s/ being read as a plural: the experimental design discouraged such readings, and *post hoc* analysis indicates that whatever plural-reading did occur leaves the effect intact. Of course, no single language is an ideal test case in every respect; further languages remain to be tested.

The article is organized as follows. Background is provided in §2 on two subjects, namely, the sonority-driven stress debate, including known stress systems sensitive to coda sonority (§2.1), and relevant background on BP and its stress system (§2.2). The experimental method is presented in §3 and results in §4, with §4.1 addressing the possible confound with plural /-s/. The discussion (§5) focuses on theoretical implications, including how best to model the results (§5.2) and implications for the sonority-driven stress debate (§5.3); §5.2 addresses the possibility that word-final /s/ is a non-moraic word-appendix, and argues that even on that analysis, sonority is what explains the non-moraicity. §6 concludes.

2 Background: sonority-driven stress and Brazilian Portuguese

2.1 Sonority-sensitive stress

Syllable weight factors into several core domains of phonology, including stress, tone, prosodic minimality, syllable structure, compensatory lengthening, meter/textsetting, end-weight, morphophonology, and others. For binary weight distinctions, two criteria prevail, with roughly equal frequency: on the first, a syllable is heavy iff it contains a long vowel (usually including diphthongs). That is, schematically, VV > {VC, V} (ignoring the onset). The other most frequent criterion treats a syllable as heavy if it has a long vowel *or coda*, that is {VV, VC} > V. Beyond these two criteria, in some systems, sonority affects weight, such that a more sonorous rime (e.g., one with a lower vowel, or a sonorant coda) counts as heavier.[2] That said, the prevalence of sonority sensitivity varies across weight-based phenomena. Sonority (at least sonorant vs. obstruent) can clearly condition weight for tone licensing (Gordon 2006: 32f), end-weight (Ryan 2019b: 169–77), meter (*ibid.*: 147–52), and syllable structure (Zec 1995: 101; Sayeed 2017). Less frequently, it conditions weight for compensatory lengthening (e.g., Kung 2007: 139f; Kiparsky 2011), reduplication (e.g., Ryan & Heath 2022), allomorphy (e.g., Anttila 1997: 5f), and perhaps minimality (cf. Ryan 2019b: 122f, 245f).

Stress, for its part, is among the weight-based phenomena for which sonority-sensitivity is less frequent. Though sonority-driven stress was once fairly uncontroversial (e.g., Hayes 1995;

[2] In the onset, the correlation between sonority and weight is reversed, such that lower sonority counts as (if anything) heavier (for reasons discussed by Goedemans 1998: 143–8; Gordon 2005: 603–7; Ryan 2014: 329; 2019b: 213f, 238f).

Kenstowicz 1997; de Lacy 2004; Gordon 2006) — Munshi & Crowhurst (2012: 429) could still refer to it in an "impressive array of languages" — more recently, several claimed cases have been reanalyzed (e.g., Rasin 2018: 44–7 on Kobon) or refuted empirically (e.g., Shih 2018 and Bowers 2019 on Gujarati), leading several scholars to call its existence in general into question. For example, Rasin (2018: 13) hypothesizes: "The distribution of stress is never conditioned by segmental features," including [±sonorant]. Likewise, Shih & de Lacy (2019: 11) (also Shih 2016) conclude: "there is no reliable evidence that metrical feet are attracted to or repelled by segments of particular sonority levels" (but see the next paragraph for qualifications). Faust & Ulfsbjorninn (2025: 19–21) too propose a reanalysis of a case in which sonorants outweigh obstruents for stress (namely, Kwak'wala; see below) and conclude that the existence of sonority-driven stress in the general case is tenuous. But not all scholars agree: Paramore (2025), for instance, allows stress to be sensitive to the sonorant vs. obstruent distinction even when both are moraic (e.g., $V_{\mu}N_{\mu} > V_{\mu}T_{\mu}$; similarly Ryan 2019b: 19).

Accounts that deny sonority-driven stress nevertheless qualify that claim in several ways. First, none treats weight distinctions between reduced and full vowels as sonority-based. Second, some of the accounts explicitly allow sonority to influence stress *indirectly*. For example, Rasin (2018: 21, 83) observes that when Latin stress differs as a function of consonant sonority (e.g., Latin [woˈlup.t̲aːs] 'pleasure' vs. [ˈwo.lu.kr̲is] 'bird'), it is because sonority conditions syllabification (which in turn conditions stress), not because stress is directly sensitive to sonority.[3] Third, Faust & Ulfsbjorninn (2025: 21) make explicit that they are concerned only with categorical rules, and the same is implicit in other accounts, none of which engage with experimental evidence for sonority sensitivity (e.g., Carpenter 2010). Fourth, Rasin (2018) and Shih & de Lacy (2019) explicitly confine their claims to stress, setting aside other weight-sensitive phenomena. Fifth, Rasin (2018) and Shih & de Lacy (2019) focus almost exclusively on *vowel* sonority. Thus, some cases in which stress appears to be determined by consonant sonority (next paragraph) go unaddressed.[4] Moreover, even for vowel sonority, perhaps not every case has been reanalyzed or refuted empirically (e.g., Kiriwina/Kilivila and Mordvin from de Lacy 2004, Cowichan from Bianco 1994). Finally, although some classic examples of sonority-driven stress are claimed to invoke gradient sonority scales (e.g., low > mid > high; Kenstowicz 1997), the literature also treats binary distinctions in sonority (e.g., an alleged low vs. non-low criterion in Gujarati) as

[3] As another example of how structure might be used to obviate direct reference to sonority, consider the famous case of Pirahã, in which voiceless/obstruent onsets are more stress-attracting than voiced/sonorant onsets (Everett & Everett 1984; Hayes 1995: 285–8; Gordon 2005: 608–18). Everett (1988: 216) analyzes Pirahã voiceless onsets as geminates. Hermans & Torres-Tamarit (2016: 5) analyze voiceless onsets as having a different adjunction site from voiced ones (syllable vs. mora).

[4] Although Shih & de Lacy (2019) do not discuss consonant sonority, consonants are in principle relevant, as they exhibit sonority levels like vowels do. That said, any VN > VT criterion that can be attributed to moras (i.e., $V_{\mu}N_{\mu} > V_{\mu}T$) need not be regarded as directly sonority-sensitive on their approach.

cases of sonority-driven stress. This last point is relevant to the present article, which argues that Portuguese stress is sensitive to a binary distinction in sonority.

Since interactions between stress and coda sonority are the focus of this article, this paragraph addresses their typology. Several potential cases appear in grammars (e.g., 3 of 107 languages surveyed by Gordon 2006), though some are underdocumented, and some potentially dubious. For example, per Levinsohn (1976: 29), Inga Quechua stress falls on the ultima only if it has a sonorant (not obstruent) coda. Nevertheless, the evidence is lacking: few examples are provided; closed ultimas are in general uncommon; and we are not aware of any corroborating phenomena or sources. Some other reported cases are in need of further research or of uncertain relevance here, including Lamang (Wolff 1983: 19), Orya (Fields 1991: 32f), Paipai (Joel 1966: 10), and Yahi (Hinton & Luthin 2002). Better established cases include Totonacan languages such as Huehuetla Tepehua (Kung 2007) and Pisaflores Tepehua (MacKay & Trechsel 2013). In these languages, primary stress is penultimate unless the ultima has a sonorant or laryngeal (but not obstruent) coda. Kraehenmann (2003: 170ff) likewise maintains that syllables ending with sonorant (but not obstruent) consonants attract stress in Thurgovian Swiss German.

Wakashan languages furnish perhaps the best-known case of coda sonority-driven stress (being, for instance, the only such case discussed by Paramore 2025 and Faust & Ulfsbjorninn 2025), though it too is debated.[5] In Kwak'wala, stress falls on the leftmost heavy syllable (or, if there is no heavy, the ultima), where a heavy contains a full vowel or a non-glottalized sonorant coda (Zec 1988; 1995; Bach et al. 2005). Elfner (2023) argues that the case reflects phrase-level prominence rather than metrical stress, but either way, "prominence placement is driven by sonority" (74). Faust & Ulfsbjorninn (2025: 20), however, propose a reanalysis that obviates reference to sonority: as they note (with Noguchi 2011: 323–5), a plain sonorant coda—the only type of "heavy" coda—always follows a schwa. This schwa, they maintain, can be analyzed as epenthetic/phonetic, such that the sonorant consonant is the nucleus. Stress then targets "the leftmost nucleus with lexical features" (i.e., full vowel or syllabic consonant), without reference to weight. The case remains open, however, as the reanalysis faces some potential issues. First, the reanalysis might not be available for related Makah or Nuu-chah-nulth, which have the same coda obstruent vs. sonorant criterion, but lack reduced vowels (Wilson 1986: 288f). Second, as Elfner (2023: 18f, 26) makes explicit, Kwak'wala permits V? rimes (where V is a full vowel) and they count as light for stress (e.g., [hə.m'a?.ˈd^{z}u] 'long soft objects'); on Faust & Ulfsbjorninn's (2025) proposal, V? is erroneously predicted to bear stress like any other full-voweled syllable. Finally, the reanalysis (as given) does not explain why glottalized sonorant codas, which must (like plain sonorant codas) be preceded by schwa, do not likewise pattern as nuclei for stress assignment.

[5] At least one non-Wakashan language in the same linguistic area, namely, the Salishan language Squamish, is likewise claimed to locate stress according to coda sonority, with the same criterion as the Wakashan languages discussed here: full vowels and plain sonorant codas are moraic; schwa, obstruent codas, and glottalized sonorant codas are not (Dyck 2004).

In summary, while different scholars operationalize “sonority-driven stress” in different ways, its existence in general is controversial. Moreover, most of the literature on the subject has focused on vowel sonority. Recent articles such as Faust & Ulfsbjorninn (2025) and Paramore (2025), however, have brought the question of whether stress can be conditioned by coda sonority back to the theoretical forefront. Reported cases in grammars are either underdocumented (e.g., Inga Quechua) or have been challenged (e.g., Kwak’wala). Against this backdrop, we turn to BP, adding new evidence about the productive application of stress to nonce words with various weight patterns and demonstrating that at least in the ultima, coda sonority determines stress placement. This is the first study to address coda sonority-driven stress experimentally, complementing the (relatively sparse) typological evidence by demonstrating its productivity in Portuguese.

2.2 Stress in Portuguese

The stress system in BP is virtually identical to that of European Portuguese. We therefore make no distinction between the two varieties, even though our data comes exclusively from the former. In this language, stress normally falls on the ultima when it is heavy (*papél* ‘paper’). Otherwise, stress falls on the penultimate syllable (*cabíde* ‘hanger’) — this is the so-called regular pattern, which accounts for approximately 70% of non-verbs in the language (Bisol 1992; Araújo 2007; Wetzels 2007; Garcia 2014). Antepenultimate stress is also attested (e.g., *abóbora* ‘pumpkin’), and has traditionally been treated as exceptional in non-verbs, though studies have identified systematic phonological and morphological generalizations in this domain (see Araújo et al. 2007; Hermans & Wetzels 2012; Garcia 2017). As in English, stress behaves differently in verbs, where it is heavily influenced by morphology (see Garcia 2025b for a recent review). Thus, it is non-verbs that provide the relevant empirical domain for testing whether coda quality affects stress preferences beyond the basic heavy/light distinction.

A heavy syllable in Portuguese contains either a diphthong or a coda consonant (vowel length is not phonemic in the language). The inventory of possible codas in the language is {s, N, l, r} (both word-internal and word-final), where N represents one of the following allophonic nasal consonants: [m, n, ŋ]. This inventory makes BP a useful test case because it provides a clear sonorant–obstruent contrast among codas, albeit one in which the obstruent side of the contrast is represented only by /s/. We show that coda /s/ behaves differently (at least in the ultima), i.e., it is less stress-attracting than the sonorant codas attested in the language. One member of the sonorant set, /l/, requires separate mention as it is typically semi-vocalized: a word like *papél* /papɛl/ is pronounced as [pa.ˈpɛw] by the vast majority of BP speakers.

A separate confound involving final /s/ is morphological: plural in Portuguese is represented by the morpheme /-s/. Since plural /-s/ does not affect the location of stress, the task of comparing obstruent and sonorant codas becomes less straightforward. Fortunately, there are monomorphemic words ending in /s/ in the lexicon, which can help us map potential sonority

effects in the language as a whole. We return to this question after presenting and discussing the results in §4.

3 Method

To examine the potential effects of coda sonority on stress, speakers of BP completed two separate tasks — an auditory forced-choice task probing stress preferences directly, and an orthographic task testing whether the same pattern surfaces in spelling.

3.1 Participants

Participants ($n = 28$) were native speakers of BP living in Canada at the time of the experiment (18 females, 10 males). They shared relatively similar characteristics with regards to education, region of origin, and linguistic background. Most participants had a bachelor's degree or a graduate degree ($n = 23$), and most came from the same two regions in Brazil, namely south and southeast ($n = 22$). The average age was 35 ($s = 9$). Almost all participants reported at least an intermediate proficiency level in English (20 reported advanced/fluent English). Some also reported some degree of fluency in Spanish and French, ranging from intermediate to advanced levels. These extralinguistic variables had no substantial impact on the patterns we discuss in this paper.

3.2 Design and materials

We designed two tasks using the Gorilla platform (Anwyl-Irvine et al. 2020) where we varied the quality of the possible coda consonants in the language: {s, N, l, r}. Task 1 was an auditory forced-choice task with different weight profiles (HLL, LHL, LLH, LLL). In this task, participants saw the orthographic form of nonce words ($n = 86$) and heard two versions of each word, i.e., minimal pairs where the only difference was the location of stress in the trisyllabic stress window. All items were recorded by a native speaker of BP with phonetic training. For LLH words, the contrast was always between final and penultimate stress, whereas for other weight profiles, the contrast was always between penultimate and antepenultimate stress. This allowed us to use penultimate stress as the reference level (versus alternative stress given weight profile) when modeling the data. Participants were asked to choose which auditory version of each nonce word they preferred, e.g., *nulquibe* (HLL) → [ˈnuw.ki.be] or [nuw.ˈki.be].

Task 2 was an orthographic task, where participants were also presented with nonce words ($n = 50$) displaying different weight profiles (HLL, LHL, LLL). Task 2 was included to test whether the same stress preferences would generalize across presentation modality, i.e., whether the sonority-sensitive pattern found in auditory stimuli would also emerge when participants inferred stress from orthographic forms alone. A carrier sentence was presented for every item (in Portuguese; translated here): *The XXX will be released at the end of the month*. Participants were always given a binary choice to fill in the blank. For example, "DIpante" versus "diPANte"

(LHL). Like Task 1, Task 2 also focused on minimal pairs where the location of stress was the only difference. Participants were told that capital letters indicated “the strongest syllable in the word.”

3.3 Procedure

To ensure the reliability of online results, some participants participated in person ($n = 11$) in a sound-attenuated room at Université Laval. The remaining participants completed the experiment remotely and resided in different cities in Canada. No meaningful differences were found between these two groups, so our discussion below will not distinguish the two methods of participation.

In both Tasks 1 and 2, participants were told that the words being evaluated had no correct pronunciation, given that they do not exist in the language. In addition, they were told that all words were in singular form and represented an object. This is important to minimize readings where participants assume they are evaluating a verb or a plural noun in the case of items ending in /s/. The distribution of items by task, weight profile, and syllable shape is summarized in Appendix A, where we also provide the full list of stimuli; the corresponding materials are available in the OSF repository listed at the end of this paper. Finally, the experiment including both tasks took approximately 20 minutes to complete, not including a short questionnaire with demographic information completed before Tasks 1 and 2.

4 Results and analysis

We begin by examining the main results from Task 1, shown in **Figure 1**. The only weight profile that deviates from an overall preference for penultimate stress is LLH, which is consistent with what is known about stress in the language. Indeed, (L)ĹH words are not uncommon in the language: *fácil* ‘easy’, *fêmur* ‘femur’, *lápis* ‘pencil’, *cadáver* ‘corpse’. As a result, the relatively high preference for penultimate stress (50%) in LLH words is not surprising, and our results are in line with previous studies on weight and stress in the language (e.g., Garcia & Goad 2024).

To examine the patterns in question, we ran a Bayesian hierarchical logistic regression using the `brms` package (Bürkner 2021) in R (R Core Team 2026). Our model predicted the log-odds of penultimate stress as a function of the weight profile of a given word. The model in question included by-speaker random intercepts and random slopes for weight, as well as by-word random intercepts. As recommended, $\hat{R}$ values were inspected (<1.01; Brooks et al. 2011), as were the effective sample sizes (ESS ≥ 716) for the posterior distributions of the main coefficients in the model. The descriptive patterns shown in **Figure 1** were corroborated by the model. Penultimate stress was statistically preferred in LLL words compared to LLH words ($\hat{\beta} = -1.49$, 95% CrI $= [-2.43, -0.59]$), supporting the view that weight effects are most likely to emerge at the right edge of the stress domain. Within words, the trends aligned with previous observations: penultimate stress was favored more in LHL than in LLL words, and slightly more in LLL than

in HLL words (where antepenultimate stress is the alternative). However, these word-internal tendencies were too weak to yield statistically reliable effects.

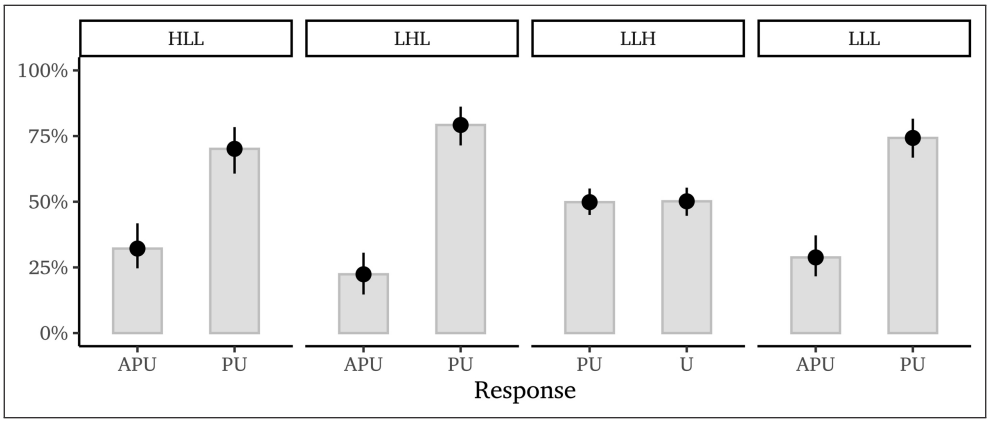


Figure 1: Main results for Task 1. Mean preference (*y*-axis) by stress location (*x*-axis) and weight. Error bars represent bootstrapped 95% confidence intervals.
APU = antepenult; PU = penult; U = ultima.

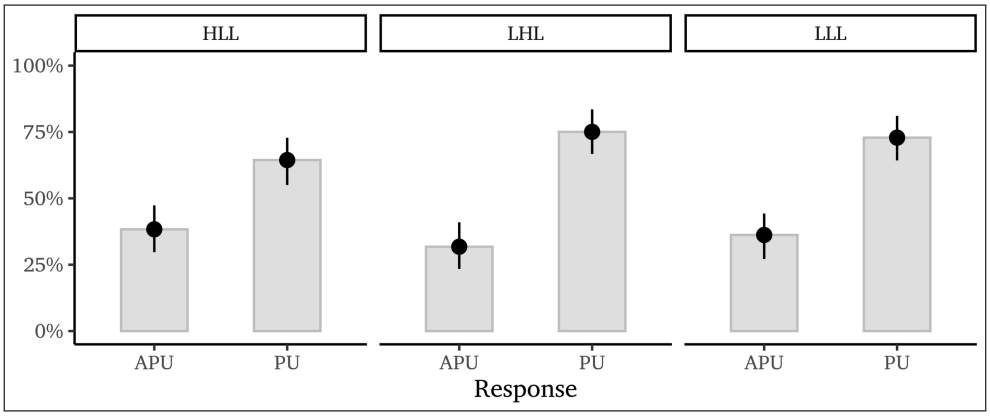


Figure 2: Main results for Task 2. Mean preference (*y*-axis) by stress location (*x*-axis) and weight. Error bars represent bootstrapped 95% confidence intervals.
APU = antepenult; PU = penult; U = ultima.

In Task 2, the orthographic task, participants favored penultimate stress across all weight profiles (**Figure 2**), confirming the general penultimate-stress bias for BP nonce words. The orthographic task tested codas only in the penult and antepenult (LHL and HLL), positions in which Task 1 also showed only weak, non-credible sonority effects; the two tasks therefore agree where they overlap. Because Task 2 did not include LLH items, it does not bear on the ultima-coda effect established by Task 1.

Let us begin our discussion on Task 1 by examining **Figure 3**. We can see that the ultima displays a clear effect of coda sonority, whereby the sonorant codas are correlated with a preference for final stress. This is confirmed by our model, which predicts the log-odds of selecting penultimate stress as a function of weight, sonority, and their interaction. The model includes this interaction as random slopes by participant, along with random intercepts by item.

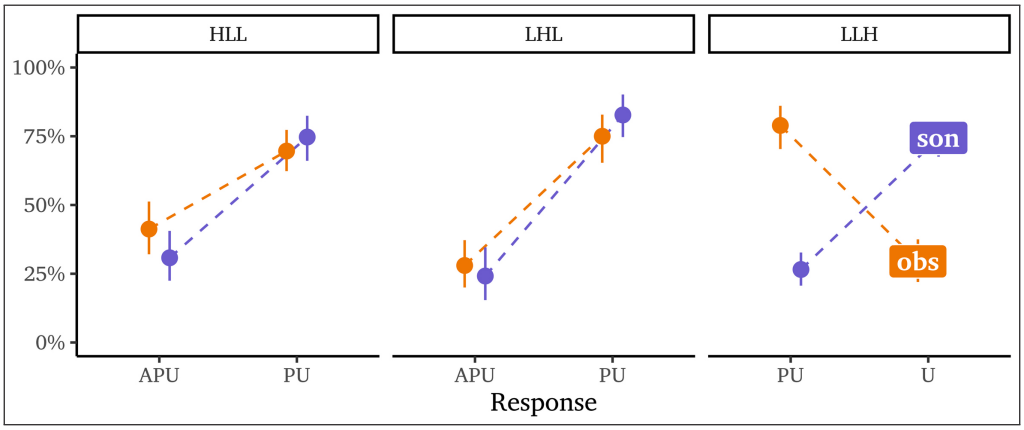


Figure 3: Mean preference (*y*-axis) by stress location (*x*-axis), weight profile and coda sonority (sonorant or obstruent) in Task 1. Error bars represent bootstrapped 95% confidence intervals. APU = antepenult; PU = penult; U = ultima.

As with the first model discussed above, we inspected both $\hat{R}$ and ESS values (ESS $\geq$ 915) for this model to ensure that our estimates are reliable and that the four chains used in the model converged. **Figure 4** shows the relevant multiple comparisons extracted from the model using the `emmeans` package (Lenth 2024); for discussion of multiplicity in Bayesian estimation, including applications to linguistic data analysis, see Garcia (2025a).

In **Figure 4**, we see a robust effect of coda sonority in the ultima: LLH words ending in /s/ are more likely to yield a preference for penultimate stress compared to LLH words ending in a sonorant. We also notice potential effects word-internally. For penultimate syllables, the negative posterior distribution of LHL obs - LHL son indicates that penultimate stress is favored more often when a sonorant coda is present in the penult. Additionally, HLL obs - HLL son indicates that antepenultimate stress is favored in the presence of an obstruent coda in antepenults. While both penultimate and antepenultimate effects are predominantly negative (suggesting possible word-internal sonority effects), their posterior distributions are too close to zero for us to draw any categorical conclusions, especially relative to the effect found for LLH obs - LLH son. We instead focus on the ultima, where the effect is clear and robust.

As mentioned earlier, BP coda /l/ is typically vocalized. We therefore also inspected /l/-final items separately. These items did not behave anomalously: in both HLL and

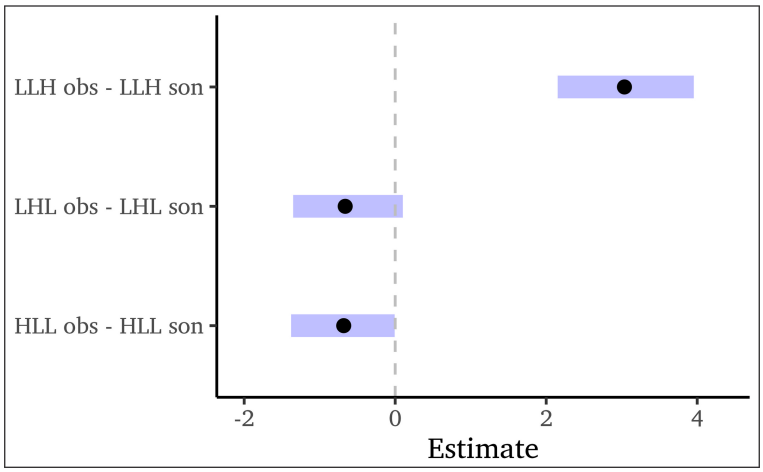


Figure 4: Model estimates (*x*-axis, in log-odds) showing multiple comparisons for the effect of sonority in Task 1 (penultimate stress) given all relevant contrasts (*y*-axis). Lines represent 95% credible intervals of posterior distributions. A positive effect indicates preference for penultimate stress.

LHL profiles, /l/ patterned with the other sonorant codas and did not drive the overall sonorant/obstruent comparison.

4.1 Morphology and final /s/

A potential concern is that the final-/s/ effect could be morphology-driven rather than sonority-driven. Portuguese plural is marked by /-s/, and plural /-s/ is invisible to stress: adding it does not shift stress or make the ultima stress-attracting. This creates a natural confound for comparing obstruent (i.e., /s/) and sonorant codas. We begin by noting that the experimental design disfavors plural readings, both in the instructions and in the use of carrier phrases incompatible with plural readings, but even so, the possible confound cannot be eliminated by design alone. This section therefore presents additional evidence that the observed sonority effect is not an artifact of participants interpreting /s/-final forms as plural. We begin with lexical evidence, followed by a discussion of individual participant behavior that applies increasingly stringent robustness checks.

First, it is important to note that monomorphemic /s/-ending words do exist in the Portuguese lexicon. Using the Portuguese Stress Lexicon as our baseline (Garcia 2014), we can easily map the stress patterns in the lexicon as a function of (final) coda quality. We can then overlay these patterns (monomorphemic words) with the patterns in the experiment — this is shown in **Figure 5**. Notice how the inversion observed in the experimental data is also observed in the lexicon. Simply put, monomorphemic words ending in /s/ are less likely to have final stress than words ending in sonorants in the lexicon. This is exactly what we observe in the experimental data discussed above.

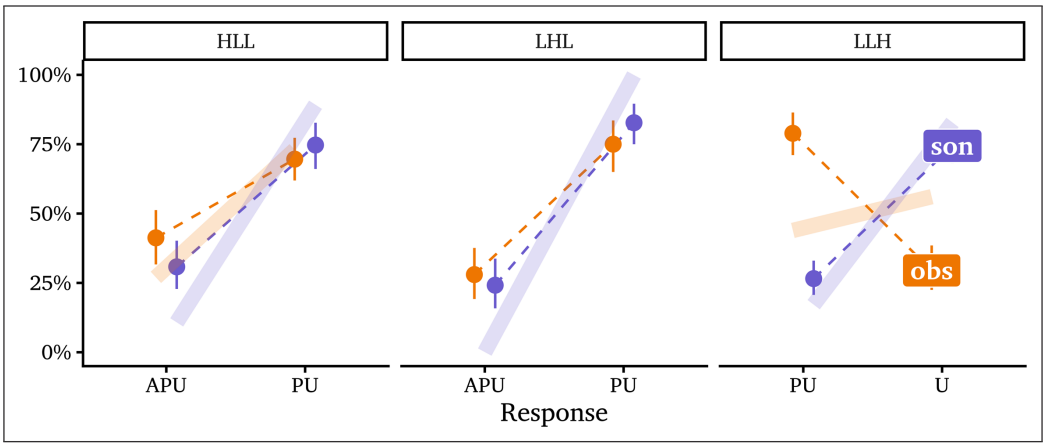


Figure 5: Lexical patterns (semitransparent thick lines) and experimental results (dashed lines). No LHL word with APU stress and an obstruent coda is found in the lexicon, hence the absence of an orange line for LHL words.

Second, we can inspect the behavior of individual participants, shown in **Figure 6**. If some participants assume that coda /s/ is plural /-s/, their preferences should be virtually categorical. While there are indeed some participants ($n = 8$) who never choose final stress in /s/-ending words, the vast majority of participants display a non-categorical pattern of behavior. Crucially, none of the participants show the opposite effect to what we find for the data as a whole.

As a robustness check, we reran the sonority model excluding the eight participants who never chose final stress for /s/-final LLH items, i.e., the participants whose behavior is most compatible with a categorical plural-reading account. The critical LLH contrast remained credible: /s/-final items continued to favor penultimate stress more than sonorant-final items ($\hat{\beta} = 2.30$, 95% CrI $= [1.46, 3.13]$). The corresponding HLL and LHL contrasts remained non-credible (HLL: $\hat{\beta} = -0.56$, 95% CrI $= [-1.32, 0.19]$; LHL: $\hat{\beta} = -0.63$, 95% CrI $= [-1.42, 0.17]$). Thus, the main sonority effect does not depend on the participants whose behavior is most plausibly attributable to a morphological effect.

Excluding participants, however, treats plural-reading as all-or-nothing, whereas **Figure 6** suggests that it is a matter of degree: a given participant might read only a subset of /s/-forms as plurals, in which case the confound would still apply to the non-categorical majority. To model this directly, we fit a hierarchical two-component mixture with participant-specific mixing weights. The model estimates, for each participant j, a latent probability π_j of their interpreting /s/-forms as plurals. Under this model, the probability of a penultimate (PU) response on an /s/-final LLH trial is $\pi_j + (1 - \pi_j)\theta_i$, where θ_i carries the usual regression structure (e.g., sonority effect, item-level variability) for the purely phonological grammar (for non-/s/-forms, only θ_i

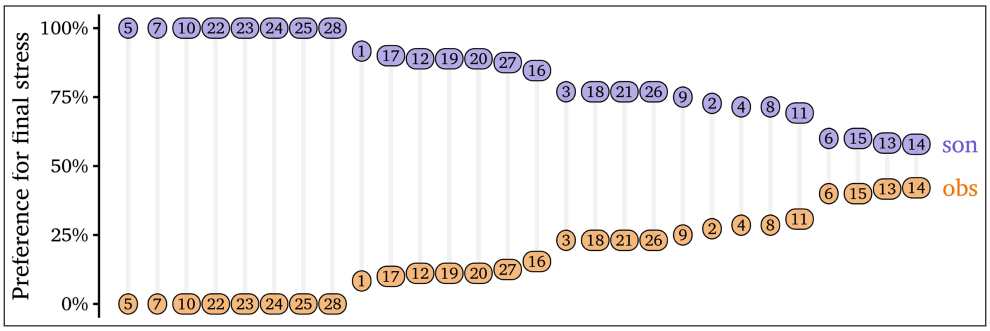


Figure 6: Individual preference for final stress as a function of coda sonority: obstruent coda in orange, sonorants in violet.

applies). The critical question is whether the obstruent-sonorant contrast survives in θ_i once π_j has absorbed whatever morphological inflation it can.

It does. The model estimates non-trivial plural-reading: the population-mean π is 0.38 (95% CrI = [0.10, 0.72]), with per-participant π_j varying continuously across [0, 1], in line with **Figure 6**. The singular-reading (i.e., pure phonology) component, however, still shows a large sonority effect in LLH: /s/-final items are predicted to receive PU on roughly 65% of trials when no plural-reading is happening, versus only 23% for sonorant-final items ($\hat{\beta}$ = 1.91, 95% CrI = [0.74, 2.93]). The observed rates are 79% and 26%, so morphology accounts for less than a quarter of the asymmetry, and most of the gap remains once it is partialed out (see **Figure 7**). Because the mixture attributes as much variance to morphology as its structure allows, the residual obstruent-sonorant gap in θ is a lower bound on the contribution of phonology.

5 Discussion

5.1 Morphology

Taken together, the evidence above limits what a morphology-based account can explain. The lexical comparison shows that the same asymmetry is present among monomorphemic words, where final /s/ is not a plural exponent. The participant-level pattern shows that only a minority behave in the categorical way expected if final /s/ is parsed as plural /-s/. A model excluding those participants still yields the same critical LLH contrast, as does a model including all participants, but allowing them to vary in their propensities to parse /s/-forms as plural. This does not eliminate morphology as a possible factor for a subset of responses, but it does indicate that the main effect cannot be reduced to plural marking. We also cannot eliminate the possibility that morphology might play an *indirect* role. One could imagine, for instance, that a preponderance of plural forms in the learning data (alongside /s/-final monomorphemes) might help learners to generalize a rule to the effect that final /s/ is non-moraic. In this manner, the phonological treatment of /s/ might not be wholly independent of the morphological status of /s/ (though, as established, even

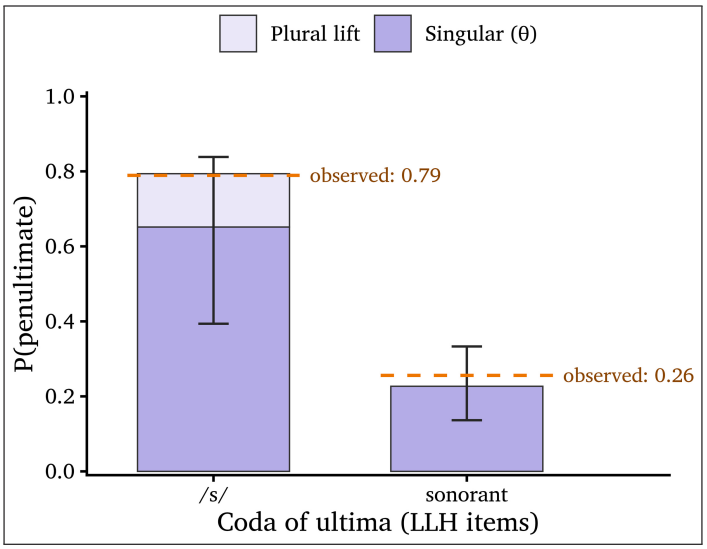


Figure 7: Mixture-model decomposition of predicted P(penultimate) on LLH trials, by ultima coda: phonological component θ (dark) plus plural-reading lift $\pi \cdot (1 - \theta)$ (light, only applies to /s/). Error bars are 95% CrIs on θ; orange ticks are raw observed proportions (slightly offset from bar tops, which are fixed-effects predictions).

monomorphemes ending with /s/ are much less likely than those ending with sonorants to take final stress).[6] This question concerns the source of the generalization — that is, diachrony or learnability — rather than its synchronic status, and thus is beyond the scope of the present experimental study.

5.2 The phonological representation of final /s/

A different concern is that BP final /s/ may be structurally special independently of morphology. On this view, the contrast would not be between sonorant vs. obstruent codas as such, but between ordinary codas and word-final /s/ with a distinct (e.g., appendix) structure. BP cannot fully resolve this question, since the language has only one obstruent coda. We argue in this section, however, that the appendix analysis is not in conflict with the sonority account. A fleshed-out version of the appendix analysis must answer why /s/, rather than codas in general, is treated as an appendix, and the best-motivated answers, we argue, involve sonority. Thus, far from undermining sonority-based weight, appendixhood is one possible implementation of it.

Two factors make the appendix analysis natural to consider for word-final /s/ in BP. First, of all segments, /s/ is cross-linguistically the most likely to be analyzed as an appendix, although most cases involve /sC/ onsets or /Cs/ codas (Kaye 1992; Vaux & Wolfe 2009; Goad 2011).

[6] Compare discussions of pseudo-plurals in Portuguese and Spanish (Bermúdez-Otero 2007; Nevins 2015).

Second, appendixhood is typologically concentrated at word peripheries (Vaux & Wolfe 2009). The relevant "light" segment in BP — word-final /s/ — combines both these properties. Even though no study has, to our knowledge, proposed that BP final /s/ is better described as an appendix, we do not rule out that possibility. However, we argue below that, like other cases of /s/ appendices, sonority still plays a key role under that analysis.

We propose that word-final /s/ (realized as [s] or [ʃ]) is non-moraic in BP. Nevins (2015: 310–2) proposes the same based on independent evidence: aside from the comparatively low rate of final stress in /s/-final monomorphemes already noted, he observes that the dialect of Rio de Janeiro epenthesizes [j] before final [ʃ] iff stress falls on the ultima (compare [a.veʃ.ˈtrujʃ] 'ostrich' to [ˈbo.nuʃ] 'bonus'), and attributes this asymmetry to STRESS-TO-WEIGHT (a stressed syllable must contain two moras). In this case, he argues, [j]-epenthesis supplies the second mora, satisfying STRESS-TO-WEIGHT, but the constraint has no effect on unstressed ultimas. This analysis depends on final /s/ being non-moraic, which Nevins (2015) posits as a general property of BP: "sibilants are not sonorous enough to be moraic." Our conclusion is essentially the same, though it hinges on independent arguments.

For present purposes, we will assume that all word-internal codas, including /s/, are moraic. The present experimental results fail to distinguish /s/ from other codas in non-final syllables, and weight sensitivity in non-final syllables is documented elsewhere (e.g., Garcia 2019). Moreover, the localization of the present sonority effect to word-final position is itself expected: BP stress is primarily weight-sensitive in the ultima (§2.2), so any sonority-driven contribution to weight should manifest most clearly there. The treatment of non-final codas is not, however, critical to what follows.

Non-moraic word-final /s/ is compatible with various structural representations. As schematized by **Figure 8**, the adjunction site of /s/ might be the mora (μ), syllable (σ), or prosodic word (ω).[7] In any case, the resulting syllable is monomoraic. Both (a) and (b) are widely employed by phonologists as the unmarked representations of monomoraic CVC syllables (e.g., (a) by Hyman 1985; Hayes 1989; 1995; (b) by Rosenthall & van der Hulst 1999; Morén 2001). Rosenthall & van der Hulst (1999: 503) refer to the coda in (b) as an APPENDIX, which they take to violate the constraint *APPEND. As they further note (following Sherer 1994), *APPEND can be regarded as a family of constraints penalizing each of (a–c): *APPEND(to-μ), *APPEND(to-σ), and *APPEND(to-ω), respectively. Note that in (b), /s/ is part of the syllable, and hence a coda, but may also be regarded as an appendix, as Rosenthall & van der Hulst (1999) do.

A word-final consonant that is ignored for weight is traditionally described as EXTRAMETRICAL (or EXTRAPROSODIC) and notated by angled brackets: CV<s>. In Optimality Theory,

[7] The foot is another logical possibility, though not often discussed as an adjunction site; moreover, the status of the foot in BP is debated (Garcia & Goad 2024). Yet another logical possibility, not often raised, is that the consonant is moraic, but the mora is extrasyllabic (cf. Topintzi & Zimmermann 2025).

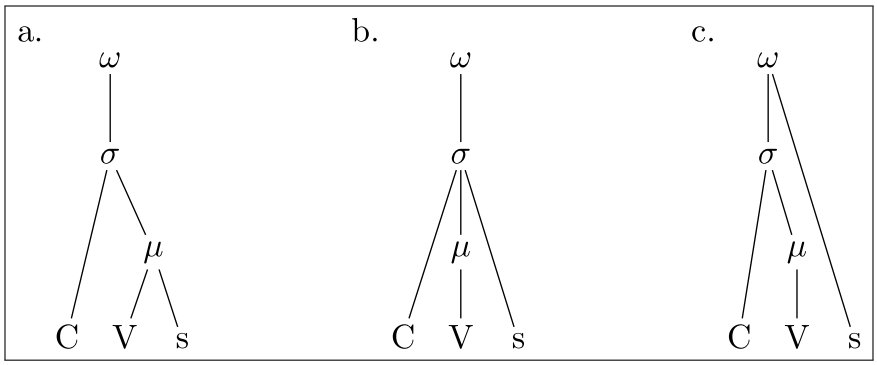
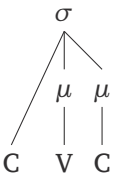


Figure 8: Possible adjunction sites of /s/.

extrametricality is usually not taken to have a formal status beyond the sorts of adjunction structures in **Figure 8** (that is, angled brackets are not formal parts of representations). For example, Kager (1999: 268) implements final consonant extrametricality using *FINAL-C-μ, which penalizes a moraic final consonant; both (b) and (c) (and possibly (a)) satisfy this constraint.

Given this background, one possible analysis of word-final /s/ takes it to be an appendix to the prosodic word, and hence non-moraic, whereas all other codas — whether word-final sonorants or word-internal — are parsed into the syllable, and hence moraic. In the formalism of Rosenthall & van der Hulst (1999), *APPEND(to-σ) is top-ranked: any coda that is parsed into a syllable must be moraic, as illustrated by tableau (1). (The constraint WEIGHT-BY-POSITION would have the same effect.)

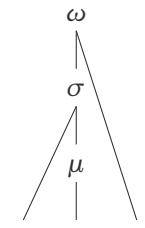
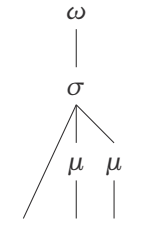
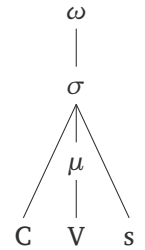
(1)

	…CVC…#	*APPEND(to-σ)
☞ a.		
b.		*!

For word-final consonants, however, an additional way to satisfy *APPEND(to-σ) becomes available: the consonant may be an appendix to the prosodic word, as shown for /s/ in tableau

(2). Because ω-adjunction is marked, some constraint must dominate *APPEND(to-ω) to compel it. Here, we employ *T_{μ}, a constraint penalizing moraic obstruents (Zec 1988; 1995; Nevins 2015). Rosenthall & van der Hulst (1999: 502) likewise explicitly acknowledge this constraint.[8]

(2)

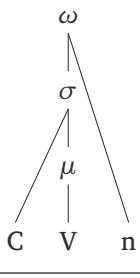
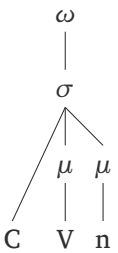
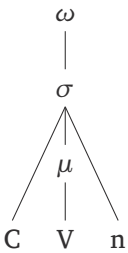
…CVs#	*APPEND(to-σ)	*T_{μ}	*APPEND(to-ω)
☞ a. 			*
b. 		*!	
c. 	*!		

As desired, a word-final sonorant, /n/ in tableau (3), remains moraic. Because *T_{μ} does not penalize moraic [n], nothing prevents it from being parsed into the syllable.[9]

[8] This constraint-based analysis could also be implemented with weighted constraints in a stochastic framework such as maxent Harmonic Grammar (Goldwater & Johnson 2003; Hayes & Wilson 2008), which could be used to implement variation in the moraicity of word-final /s/. We remain open to the possibility that final /s/ might not be *categorically* non-moraic; what is important is that it is *less likely* to be moraic than final sonorants.

[9] Tableau (3) shows no violations for candidate (b), but (b) violates low-ranked constraints (not shown) such as *C_{μ} and NOCODA. Furthermore, we do not show candidates with extrasyllabic moras (e.g., moraic /n/ attaching directly to ω). If such candidates are possible, they can be ruled out by high-ranked $\mu > \sigma$, which requires moras to be syllabically licensed (Topintzi & Zimmermann 2025: 317).

(3)

…CVn#	*APPEND(to-σ)	*T_μ	*APPEND(to-ω)
a. 			∗!
☞ b. 			
c. 	∗!		

While not the only possible analysis, this analysis illustrates that the possibility of ω-appendixhood does not in itself oppose the sonority-based explanation. On the contrary, sonority can explain why /s/, on such an analysis, is an appendix. That said, if one were to substitute a hypothetical constraint such as *SIBCODA (penalize a sibilant coda) in place of *T_μ above, the analysis would still work. *SIBCODA, like *T_μ, would have the effect of pushing the sibilant out of the syllable. However, *SIBCODA is more *ad hoc*: it singles out a phoneme (ironically, the only obstruent that *is* allowed as a coda in BP), has less typological backing than *T_μ, and lacks independent support, in the sense that no one to our knowledge has proposed that word-final /s/ is not a coda in BP, as mentioned earlier. If *X-CODA constraints can be freely stipulated, why do we not find languages in which, say, *SONCODA (or **n*-CODA) drives sonorants (or just [n]) into appendix position? In the typology of weight-sensitive phenomena (§2.1), languages restrict coda weight along the obstruent/sonorant divide, not along the sibilant/non-sibilant or any other arbitrary divide. Moreover, previous discussions of /s/-extrametricality in BP (e.g., Kaye 1992;

Goad 2011) concern only /sC/ onset clusters, where appendixhood is motivated by the Sonority Sequencing Principle.[10]

Still other analyses are conceivable. For example, Paramore (2025: 16) argues that codas are universally moraic, and accounts for coda sonority-driven stress using the constraint S→$[\mu_R\mu_R]_\sigma$, which requires stress (S) to fall on a syllable with two sonorant moras (μ_R). With such a constraint, all codas could be analyzed as moraic in all positions in BP (i.e., simple weight-by-position). This approach would need to be fleshed out for BP in order to limit the distinction between codas to the ultima. At any rate, this line of analysis once again adopts a sonority-driven stress approach.

Taken together with the morphological argumentation in §4.1, we take the BP data to support a limited but robust conclusion: final sonorant codas are more stress-attracting than final /s/ in BP nonce words, along with the lexicon, and this asymmetry resists reduction either to plural morphology or to a sonority-free appendix account. Indeed, the localization of the asymmetry to final position — the same position where weight is otherwise most relevant to BP stress — is what a sonority-driven weight account predicts. While word-peripheral /s/ is analyzed as an appendix in some languages, its appendixhood in well-studied cases is not merely stipulated ("sibilants prefer to be appendices"), but independently motivated by sonority,[11] and we argue that the same applies here if an appendix analysis is employed.

5.3 Brazilian Portuguese and sonority-driven stress

Finally, we return to the question of how the present case relates to the recent skepticism about sonority-driven stress. The BP pattern — stress placement is conditioned by whether the final coda is a sonorant or an obstruent — is sonority-driven stress in the broad descriptive sense, and it can be analyzed as such directly (e.g., using Paramore's 2025 constraint S→$[\mu_R\mu_R]_\sigma$, as discussed in §5.2). Nevertheless, in §5.2, we also considered an appendix-based analysis, in which *T_μ causes word-final /s/ to be realized as a ω-appendix, and thus non-moraic. Whether this latter analysis fits the definition of "sonority-driven stress" depends on how the analyst defines the term.

Recall from §2.1 that Rasin (2018) proposes the STRESS ENCAPSULATION UNIVERSAL, according to which "[t]he distribution of stress is never conditioned by segmental features" (including sonority). Nevertheless, Rasin (2018) allows sonority to influence stress indirectly, via syllable structure, and does not count such cases as violating the proposed universal. As such a case, he gives the example of Latin [woˈlup.taːs] 'pleasure' vs. [ˈwo.lu.kris] 'bird', where sonority determines how the interlude ([p.t] vs. [.kr]) is syllabified, and hence the weight of the penult. While one might expect that the appendix analysis of BP would be regarded as another case of

[10] Yet another constraint that would work in lieu of *T_μ is *OBSCODA, penalizing any obstruent coda. *OBSCODA, unlike *SIBCODA, is well motivated typologically, in that some languages limit codas to sonorants. Importantly, however, *OBSCODA explicitly invokes sonority, so the conclusion would remain that moraicity is being determined in some manner by sonority.

[11] Vaux & Wolfe (2009: 103) note that the Sonority Sequencing Principle is "the most prevalent rationale for positing extrasyllabicity," and argue against positing extrasyllabicity without independent motivation (104).

the same indirect conditioning — sonority conditions prosodic structure, which in turn conditions stress, in parallel with the Latin case — in practice, Rasin (2018: 20–2) employs a CV tier rather than arboreal prosodic phonology, and does not address phonological appendices,[12] so we will not speak for how the appendix analysis in §5.2 might map onto that approach. At any rate, we acknowledge that the appendix analysis of BP is at least consistent with the spirit of the argument that structural considerations can obviate direct reference by stress to sonority.

Similarly, Shih & de Lacy (2019), in arguing against the existence of sonority-driven stress, circumscribe the phenomenon narrowly (see §2.1), allowing that "sonority can indirectly affect metrical structure: if segments of certain sonority are required to have particular moraic configurations and metrical structure is appropriately sensitive to moraic content, then segmental sonority can appear to influence metrical structure" (10). This distinction between stress being mediated by sonority vs. moraicity is especially meaningful for vowel-sonority cases, which are the focus of Shih & de Lacy (2019). If all vowels are moraic, but lower vowels nevertheless pattern as more stress-attracting — or if there is a gradient effect such as low > mid > high — then constraints on stress/feet must directly invoke sonority.

In the context of coda sonority, however, the same operationalization of direct vs. indirect is less probative, since consonants can more readily be analyzed as differing in moraicity. In particular, any VN > VT criterion for stress that can be analyzed with N alone being moraic (e.g., via *T_{μ}) does not count as "sonority-driven stress" under this definition. Qualifying cases would have to include both a VN > VT criterion for stress and independent evidence that the stress system treats both N and T codas as moraic. While such cases are conceivable and have even been put forth,[13] this is a high bar, and yields a narrower sense of "sonority-driven stress" than the prevailing usage in the context of consonants. For example, Kwak'wala (§5.2), a canonical putative case (cf. e.g., Rasin 2018: 83, Faust & Ulfsbjorninn 2025: 20), would not count as such, provided that sonorant codas are simply deemed moraic. This divergence between the narrow technical sense vs. common descriptive sense of "sonority-driven stress" matters for how claims about the typology are received: a reader who interprets "sonority-driven stress does not exist" in the broad sense risks concluding that VN > VT patterns are unattested, when analysts' actual claim is the narrower one that such patterns are mediated by moraic structure.

In sum, the classification of BP depends on what one takes "sonority-driven stress" to require. On a broad descriptive use of the term, BP is plainly a case: stress preferences differ according to the sonority of the final coda. In a narrower sense, there are analyses available for BP in which sonority conditions moraicity, which in turn conditions stress, such that constraints

[12] Rasin (2018: 82) does discuss the extrametricality of English *-y*, but tentatively attributes it to the morphology rather than the phonology.

[13] For example, Ryan (2019a) argues that the productive coda sonority effect in binomials (e.g., type *thick and thin* in English) is a weight effect (VN > VT) driven by phrasal stress; in that context, both codas are moraic, as prosodic words must be bimoraic in English. For Paramore (2025), which treats all codas as moraic, any VN > VT criterion trivially and necessarily counts as sonority-driven.

on stress need not *directly* reference sonority. Setting aside questions of how exactly sonority affects stress placement in various frameworks, however, it bears repeating that the typology furnishes relatively few cases in which the sonority levels of consonants descriptively affect stress placement. There is even less experimental investigation of such cases. The present article contributes new evidence on both fronts, furnishing experimental evidence for a productive consonant-sonority asymmetry in BP.

6 Final remarks

This article has presented experimental evidence that coda sonority influences stress placement in Brazilian Portuguese. Speakers systematically prefer final stress when the ultima ends in a sonorant {N, l, r} compared to the obstruent /s/, reflecting and amplifying the same asymmetry found in existing monomorphemic words. As we have argued, this effect cannot be reduced to /s/ being interpreted (even stochastically) as a plural suffix.

As for the phonological modeling of these results, various analyses are available, including indexing stress directly to sonority (e.g., Paramore 2025) or, alternatively, rendering /s/ as a non-moraic appendix to the prosodic word. Even on the latter analysis, however, a principled analysis of appendixhood involves sonority, such that the case remains one of sonority-driven stress in the broad sense. Whether the sonority-sensitivity is direct or indirect depends on the framework/analysis and how the analyst operationalizes those terms, as just discussed in §5.3. At any rate, an ultima-only effect is consistent with how weight in general works in BP, given that sensitivity is strongest in the ultima and attenuates earlier in the word (Garcia 2019).[14]

Beyond BP, the study bears on the broader debate over whether stress placement can be conditioned by segmental sonority. The typological evidence is contested, with several previously canonical cases having been reanalyzed or empirically challenged (§2.1). Experimental evidence, meanwhile, has been comparatively scarce: Carpenter (2010) provides artificial-grammar evidence that vowel sonority can influence stress, but to our knowledge no prior study has examined coda sonority experimentally (except as the condition mentioned in footnote 14).[15] BP, like any single language, has limits as a test case. In particular, it has only one obstruent coda, being the sibilant. Parallel studies in other languages, perhaps with richer coda inventories, and perhaps with weight sensitivity outside of the ultima, would help to clarify the synchronic status of coda-sonority effects on stress, as evidence continues to develop on both the typological and experimental fronts.

---

[14] Garcia & Goad (2024), however, do find a credible effect of coda sonority in the BP antepenult, such that an antepenult with a sonorant coda attracts stress more than one with an /s/ coda ($\hat{\beta}$ = 0.40, 95% CrI = [0.00, 0.82]). No comparable effect emerges in the present results. Whether this difference reflects the subtler/gradient character of non-final weight effects in BP or methodological differences we leave to future work.

[15] Shelton (2007) and Shelton & Grant (2018) present experimental evidence for gradient weight in Spanish, showing that falling diphthongs > rising diphthongs > monophthongs, but do not test segmental sonority.

Appendix A: Stimuli

Table 1 summarizes the distribution of items by task, weight profile, and syllable shape. **Tables 2** and **3** list the stimuli used in the auditory forced-choice task and the orthographic task, respectively. The class column distinguishes obstruent codas (obs), sonorant codas (son), and fillers without codas. For Task 1, APU, PU, and U indicate stress on the antepenult, penult, and ultima; for Task 2, capitalization marks the stressed syllable shown to participants.

Table 1: Number of stimuli by task, weight profile, and syllable shape.

Task	Weight	Shape	*n*
1	HLL	CVC.CV.CV	22
1	LHL	CV.CVC.CV	22
1	LLH	CV.CV.CVC	22
1	LLL	CCV.CV.CV	8
1	LLL	CV.CCV.CV	6
1	LLL	CV.CV.CCV	6
2	HLL	CVC.CV.CV	20
2	LHL	CV.CVC.CV	20
2	LLL	CCV.CV.CV	3
2	LLL	CV.CCV.CV	3
2	LLL	CV.CV.CCV	4

Table 2: Stimuli for Task 1, the auditory forced-choice task.

No.	Word	Type	Weight	Coda	Class	Options
1	nulquibe	target	HLL	l	son	APU–PU
2	mulugues	target	LLH	s	obs	PU–U
3	supitir	target	LLH	r	son	PU–U
4	sidigas	target	LLH	s	obs	PU–U
5	gusdime	target	HLL	s	obs	APU–PU
6	bicaste	target	LHL	s	obs	APU–PU
7	fibilme	target	LHL	l	son	PU–APU
8	docrano	filler	LLL	–	–	PU–APU
9	pintaja	target	HLL	N	son	PU–APU

(Contd.)

No.	Word	Type	Weight	Coda	Class	Options
10	fupipar	target	LLH	r	son	U–PU
11	ticaste	target	LHL	s	obs	PU–APU
12	casbite	target	HLL	s	obs	APU–PU
13	frozova	filler	LLL	–	–	PU–APU
14	zufagos	target	LLH	s	obs	PU–U
15	suvipir	target	LLH	r	son	PU–U
16	mitirde	target	LHL	r	son	APU–PU
17	gofapra	filler	LLL	–	–	PU–APU
18	pilsuque	target	HLL	l	son	PU–APU
19	machipro	filler	LLL	–	–	APU–PU
20	tirdabo	target	HLL	r	son	APU–PU
21	zudibil	target	LLH	l	son	U–PU
22	vanchito	target	HLL	N	son	APU–PU
23	tugusbe	target	LHL	s	obs	PU–APU
24	cronapo	filler	LLL	–	–	PU–APU
25	fuguisda	target	LHL	s	obs	APU–PU
26	gusfuvo	target	HLL	s	obs	APU–PU
27	dabucas	target	LLH	s	obs	PU–U
28	sifuvan	target	LLH	N	son	PU–U
29	faguspo	target	LHL	s	obs	PU–APU
30	guelubro	filler	LLL	–	–	PU–APU
31	nulticho	target	HLL	l	son	PU–APU
32	parcata	target	HLL	r	son	PU–APU
33	drelaja	filler	LLL	–	–	APU–PU
34	lugusde	target	LHL	s	obs	PU–APU
35	taguisno	target	LHL	s	obs	PU–APU
36	guistafa	target	HLL	s	obs	PU–APU
37	gutapin	target	LLH	N	son	PU–U
38	guismulo	target	HLL	s	obs	PU–APU
39	quezatre	filler	LLL	–	–	PU–APU
40	pinchibo	target	HLL	N	son	PU–APU
41	tiguste	target	LHL	s	obs	PU–APU
42	frodazo	filler	LLL	–	–	PU–APU
43	gustube	target	HLL	s	obs	PU–APU
44	cunagos	target	LLH	s	obs	PU–U

(Contd.)

No.	Word	Type	Weight	Coda	Class	Options
45	gusnape	target	HLL	s	obs	APU–PU
46	dassupro	filler	LLL	–	–	APU–PU
47	cabigues	target	LLH	s	obs	PU–U
48	casdabo	target	HLL	s	obs	APU–PU
49	bapinzo	target	LHL	N	son	PU–APU
50	ditirso	target	LHL	r	son	PU–APU
51	lidagas	target	LLH	s	obs	PU–U
52	nutucal	target	LLH	l	son	U–PU
53	fubilno	target	LHL	l	son	PU–APU
54	birvude	target	HLL	r	son	APU–PU
55	zefrano	filler	LLL	–	–	APU–PU
56	muvralo	filler	LLL	–	–	PU–APU
57	chipimbo	target	LHL	N	son	PU–APU
58	nubigues	target	LLH	s	obs	PU–U
59	vaparze	target	LHL	r	son	PU–APU
60	fucasbe	target	LHL	s	obs	APU–PU
61	falupin	target	LLH	N	son	U–PU
62	zitirvo	target	LHL	r	son	PU–APU
63	zibulan	target	LLH	N	son	PU–U
64	ludigas	target	LLH	s	obs	U–PU
65	vinulto	target	LHL	l	son	PU–APU
66	pugrase	filler	LLL	–	–	PU–APU
67	guistide	target	HLL	s	obs	PU–APU
68	dipunte	target	LHL	N	son	APU–PU
69	grotusa	filler	LLL	–	–	APU–PU
70	zobepre	filler	LLL	–	–	PU–APU
71	gurchute	target	HLL	r	son	APU–PU
72	litunal	target	LLH	l	son	U–PU
73	casmite	target	HLL	s	obs	APU–PU
74	guilucas	target	LLH	s	obs	U–PU
75	bilzude	target	HLL	l	son	PU–APU
76	vucrete	filler	LLL	–	–	PU–APU
77	croleda	filler	LLL	–	–	PU–APU
78	cudregue	filler	LLL	–	–	APU–PU

(Contd.)

No.	Word	Type	Weight	Coda	Class	Options
79	lipunta	target	LHL	N	son	APU–PU
80	tinugur	target	LLH	r	son	U–PU
81	bubilga	target	LHL	l	son	APU–PU
82	nidutal	target	LLH	l	son	PU–U
83	drabuche	filler	LLL	–	–	PU–APU
84	brilode	filler	LLL	–	–	PU–APU
85	pindaque	target	HLL	N	son	PU–APU
86	bugusto	target	LHL	s	obs	PU–APU

Table 3: Stimuli for Task 2, the orthographic task.

No.	Word	Type	Weight	Coda	Class	Options
1	di.pan.te	target	LHL	N	son	DIpante–diPANte
2	kas.ta.te	target	HLL	s	obs	CAState–casTAte
3	mal.ti.se	target	HLL	l	son	malTIse–MALtise
4	bu.van.fo	target	LHL	N	son	buVANfo–BUvanfo
5	per.ka.ta	target	HLL	r	son	perCAta–PERcata
6	gas.ti.de	target	HLL	s	obs	gasTIde–GAStide
7	fri.da.zo	filler	LLL	–	–	FRIdazo–friDAzo
8	go.fu.pra	filler	LLL	–	–	goFUpra–GOfupra
9	tu.gas.be	target	LHL	s	obs	TUgasbe–tuGASbe
10	kes.da.bo	target	HLL	s	obs	quesDAbo–QUESdabo
11	nul.ti.cho	target	HLL	l	son	NULticho–nulTIcho
12	mu.van.go	target	LHL	N	son	muVANgo–MUvango
13	ba.mal.fa	target	LHL	l	son	baMALfa–BAmalfa
14	tar.da.bo	target	HLL	r	son	tarDAbo–TARdabo
15	zi.fra.no	filler	LLL	–	–	ziFRAno–ZIfrano
16	ga.lu.bro	filler	LLL	–	–	gaLUbro–GAlubro
17	pim.pa.te	target	HLL	N	son	PIMpate–pimPAte
18	gre.tu.sa	filler	LLL	–	–	GREtusa–greTUsa
19	mi.kas.te	target	LHL	s	obs	miCASte–MIcaste
20	lu.mal.ba	target	LHL	l	son	LUmalba–luMALba

(Contd.)

No.	Word	Type	Weight	Coda	Class	Options
21	van.ti.po	target	HLL	N	son	vanTIpo–VANtipo
22	ki.van.se	target	LHL	N	son	QUIvanse–quiVANse
23	fu.kos.be	target	LHL	s	obs	FUcosbe–fuCOSbe
24	ti.gos.te	target	LHL	s	obs	tiGOSte–TIgoste
25	kas.ka.mo	target	HLL	s	obs	casCAmo–CAScamo
26	pen.ta.ja	target	HLL	N	son	PENtaja–penTAja
27	mi.tur.de	target	LHL	r	son	MIturde–miTURde
28	mu.chi.pro	filler	LLL	–	–	MUchipro–muCHIpro
29	si.vam.be	target	LHL	N	son	siVAMbe–SIvambe
30	gos.ta.fa	target	HLL	s	obs	GOStafa–gosTAfa
31	par.gi.le	target	HLL	r	son	PARgile–parGIle
32	fe.gus.po	target	LHL	s	obs	feGUSpo–FEguspo
33	va.kre.te	filler	LLL	–	–	VAcrete–vaCREte
34	gas.di.me	target	HLL	s	obs	gasDIme–GASdime
35	kes.bi.te	target	HLL	s	obs	quesBIte–QUESbite
36	bil.fu.no	target	HLL	l	son	bilFUno–BILfuno
37	kri.na.po	filler	LLL	–	–	CRInapo–criNApo
38	pu.gas.de	target	LHL	s	obs	PUgasde–puGASde
39	vu.par.te	target	LHL	r	son	vuPARte–VUparte
40	ka.dre.ge	filler	LLL	–	–	caDREge–CAdrege
41	kas.pu.ze	target	HLL	s	obs	CASpuze–casPUze
42	bi.kos.te	target	LHL	s	obs	BIcoste–biCOSte
43	za.be.pre	filler	LLL	–	–	zaBEpre–ZAbepre
44	kas.da.bo	target	HLL	s	obs	CASdabo–casDAbo
45	fa.gis.da	target	LHL	s	obs	FAgisda–faGISda
46	mi.par.la	target	LHL	r	son	miPARla–MIparla
47	gas.tu.be	target	HLL	s	obs	GAStube–gasTUbe
48	gi.kas.fe	target	LHL	s	obs	giCASfe–GIcasfe
49	ti.kos.te	target	LHL	s	obs	TIcoste–tiCOSte
50	nal.ki.be	target	HLL	l	son	nalQUIbe–NALquibe

Data availability

The stimuli, data and script for this paper are available at https://osf.io/fuy7d/.

Ethics and consent

This study was approved by *Le Comité plurifacultaire d'éthique de la recherche* at Université Laval (approval no. 2024-122 R-1).

Funding information

This work was supported by the Social Sciences and Humanities Research Council of Canada (Insight Development Grant no. 430-2024-00159 to Guilherme D. Garcia). The 2024 research visit to Harvard University during which this project was initiated was made possible by Université Laval's *Programme de mobilité professorale* (grant no. DR140407).

Acknowledgements

The authors wish to thank Natália B. Guzzo. Guilherme D. Garcia also thanks the Department of Linguistics at Harvard University for hosting him during the 2024 research visit at which this project was initiated.

Competing interests

The authors have no competing interests to declare.

References

Anttila, Arto. 1997. Deriving variation from grammar. In Hinskens, Frans & van Hout, Roeland & Wetzels, Leo (eds.), *Variation, change and phonological theory*, 35–68. Amsterdam: John Benjamins. DOI: https://doi.org/10.1075/cilt.146.04ant

Anwyl-Irvine, Alexander L. & Massonnié, Jessica & Flitton, Adam & Kirkham, Natasha Z. & Evershed, Jonathan K. 2020. Gorilla in our midst: An online behavioral experiment builder. *Behavior Research Methods* 52(1). 388–407. DOI: https://doi.org/10.3758/s13428-019-01237-x

Araújo, Gabriel Antunes. 2007. *O acento em português: abordagens fonológicas*. São Paulo: Parábola.

Araújo, Gabriel Antunes & Guimarães-Filho, Zwinglio Oliveira & Oliveira, Leonardo & Viaro, Mário. 2007. As proparoxítonas e o sistema acentual do português. In Araújo, Gabriel Antunes (ed.), *O acento em português: abordagens fonológicas*, 37–60. São Paulo: Parábola.

Bach, Emmon & Howe, Darin & Shaw, Patricia. 2005. On epenthesis and moraicity in Northern Wakashan. Paper presented at the *Society for the Study of the Indigenous Languages of the Americas*.

Bermúdez-Otero, Ricardo. 2007. Spanish pseudoplurals: Phonological cues in the acquisition of a syntax-morphology mismatch. In Baerman, Matthew & Corbett, Greville G. & Brown, Dunstan & Hippisley, Andrew (eds.), *Deponency and morphological mismatches*, vol. 145 (Proceedings of the British Academy), 231–269. Oxford: Oxford University Press. DOI: https://doi.org/10.5871/bacad/9780197264102.003.0010

Bianco, Violet Myrle. 1994. *The role of sonority in the prosody of Cowichan*. University of Victoria dissertation.

Bisol, Leda. 1992. O acento e o pé métrico binário. *Cadernos de Estudos Linguísticos* 22. 69–80.

Bowers, Dustin. 2019. Positional vs. sonority-driven stress in Gujarati: New experimental evidence. *Phonological Data and Analysis* 1(1). 1–28. DOI: https://doi.org/10.3765/pda.v1art1.19

Brooks, Steve & Gelman, Andrew & Jones, Galin & Meng, Xiao-Li. 2011. *Handbook of Markov Chain Monte Carlo*. Boca Raton: Chapman and Hall/CRC.

Bürkner, Paul-Christian. 2021. Bayesian item response modeling in R with `brms` and Stan. *Journal of Statistical Software* 100(5). 1–54. DOI: https://doi.org/10.18637/jss.v100.i05

Carpenter, Angela C. 2010. A naturalness bias in learning stress. *Phonology* 27. 345–392. DOI: https://doi.org/10.1017/s0952675710000199

de Lacy, Paul. 2004. Markedness conflation in Optimality Theory. *Phonology* 21(2). 145–199. DOI: https://doi.org/10.1017/S0952675704000193

Dyck, Ruth Anne. 2004. *Prosodic and morphological factors in Squamish (Sḵwx̱wú7mesh) stress assignment*. University of Victoria dissertation.

Elfner, Emily. 2023. *Prosody and prosodic phrasing in Kwak'wala*. Slides from the University of Calgary Linguistics Colloquium, November 10.

Everett, Daniel. 1988. On metrical constituent structure in Pirahã. *Natural Language and Linguistic Theory* 6. 207–246. DOI: https://doi.org/10.1007/BF00134230

Everett, Daniel & Everett, Keren. 1984. On the relevance of syllable onsets to stress placement. *Linguistic Inquiry* 15. 705–711.

Faust, Noam & Ulfsbjorninn, Shanti. 2025. The typology of weight in strict CV metrics: A challenge to moraic theory. *Linguistic Inquiry* 56. 1–60. DOI: https://doi.org/10.1162/ling.a.58

Fields, Philip C. 1991. A phonology of the Orya language. In Dutton, Tom (ed.), *Papers in Papuan linguistics*, vol. 1, 29–56. Canberra: The Australian National University.

Garcia, Guilherme D. 2014. *Portuguese stress lexicon*. Comprehensive list of non-verbs in Portuguese. Available at http://gdgarcia.ca/psl.html.

Garcia, Guilherme D. 2017. *Weight effects on stress: Lexicon and grammar*. McGill University dissertation. DOI: https://doi.org/10.31219/osf.io/bt8hk

Garcia, Guilherme D. 2019. When lexical statistics and the grammar conflict: Learning and repairing weight effects on stress. *Language* 95(4). 612–641. DOI: https://doi.org/10.1353/lan.2019.0068

Garcia, Guilherme D. 2025a. Bayesian estimation in multiple comparisons. *Studies in Second Language Acquisition* 47(3). 885–911. DOI: https://doi.org/10.1017/s0272263125100922. https://gdgarcia.ca/multcomp

Garcia, Guilherme D. 2025b. Current issues in Portuguese main and secondary stress. In Zampaulo, André (ed.), *The Routledge Handbook of Portuguese Phonology*. London: Routledge. DOI: https://doi.org/10.4324/9781003266648-9. Pre-print available at https://doi.org/10.31219/osf.io/6dpa5

Garcia, Guilherme D. & Goad, Heather. 2024. Weight effects and the parametrization of the foot: English versus Portuguese. *Laboratory Phonology* 15(1). 1–37. DOI: https://doi.org/10.16995/labphon.6420

Goad, Heather. 2011. The representation of sC clusters. In van Oostendorp, Marc & Ewen, Colin J. & Hume, Elizabeth & Rice, Karen (eds.), *The Blackwell companion to phonology*, 898–923. Wiley Online Library.

Goedemans, Rob. 1998. *Weightless segments*. The Hague: Holland Academic Graphics.

Goldwater, Sharon & Johnson, Mark. 2003. Learning OT constraint rankings using a Maximum Entropy model. In Spenader, Jennifer & Eriksson, Anders & Dahl, Osten (eds.), *Proceedings of the Stockholm Workshop on Variation within Optimality Theory*, 111–120.

Gordon, Matthew. 2005. A perceptually-driven account of onset-sensitive stress. *Natural Language and Linguistic Theory* 23. 595–653. DOI: https://doi.org/10.1007/s11049-004-8874-9

Gordon, Matthew. 2006. *Syllable weight: phonetics, phonology, typology*. New York, NY: Routledge Press. DOI: https://doi.org/10.4324/9780203944028

Hayes, Bruce. 1989. Compensatory lengthening in moraic phonology. *Linguistic Inquiry* 20. 253–306.

Hayes, Bruce. 1995. *Metrical stress theory: Principles and case studies*. Chicago, IL: University of Chicago Press.

Hayes, Bruce & Wilson, Colin. 2008. A Maximum Entropy model of phonotactics and phonotactic learning. *Linguistic Inquiry* 39. 379–440. DOI: https://doi.org/10.1162/ling.2008.39.3.379

Hermans, Ben & Torres-Tamarit, Francesc. 2016. Onset weight with branchingness constraints: The case of Pirahã. *Proceedings of the Annual Meeting on Phonology 2015*, 1–9. DOI: https://doi.org/10.3765/amp.v3i0.3655

Hermans, Ben & Wetzels, Leo. 2012. Productive and unproductive stress patterns in Brazilian Portuguese. *Revista Letras & Letras* 28. 77–114.

Hinton, Leanne & Luthin, Herb. 2002. Stress & syllable weight in Yahi. Paper presented at the *Society for the Study of the Indigenous Languages of the Americas*.

Hyman, Larry M. 1985. *A theory of phonological weight*. Dordrecht: Foris. DOI: https://doi.org/10.1515/9783110854794

Joel, Dina Judith. 1966. *Paipai phonology and morphology*. University of California, Los Angeles dissertation.

Kager, René. 1999. *Optimality Theory*. Cambridge, U.K.: Cambridge University Press. DOI: https://doi.org/10.1017/cbo9780511812408

Kaye, Jonathan. 1992. Do you believe in magic? The story of s+C sequences. *SOAS Working Papers in Linguistics and Phonetics* 2. 293–313.

Kenstowicz, Michael. 1997. Quality-sensitive stress. *Rivista di Linguistica* 9. 157–187.

Kiparsky, Paul. 2011. Compensatory lengthening. In Cairns, Charles & Raimy, Eric (eds.), *Handbook of the syllable*, 33–70. Leiden: Brill. DOI: https://doi.org/10.1163/ej.9789004187405.i-464.10

Kraehenmann, Astrid. 2003. *Quantity and prosodic asymmetries in Alemannic: Synchronic and diachronic perspectives*. Berlin: Mouton de Gruyter. DOI: https://doi.org/10.1515/9783110197228

Kung, Susan Smythe. 2007. *A descriptive grammar of Huehuetla Tepehua*. University of Texas, Austin dissertation.

Lenth, Russell V. 2024. *emmeans: Estimated marginal means, aka least-squares means*. https://CRAN.R-project.org/package=emmeans. R package version 1.10.1.

Levinsohn, Stephen H. 1976. *The Inga language*. The Hague: Mouton. DOI: https://doi.org/10.1515/9783110819120

MacKay, Carolyn J. & Trechsel, Frank R. 2013. A sketch of Pisaflores Tepehua phonology. *International Journal of American Linguistics* 79(2). 189–218. DOI: https://doi.org/10.1086/669628

Morén, Bruce T. 2001. *Distinctiveness, coercion and sonority: A unified theory of weight*. London: Routledge. DOI: https://doi.org/10.4324/9781315023779

Munshi, Sadaf & Crowhurst, Megan J. 2012. Weight sensitivity and syllable codas in Srinagar Koshur. *Journal of Linguistics* 48. 427–472. DOI: https://doi.org/10.1017/s0022226712000096

Nevins, Andrew. 2015. Review of Natalie Operstein, *Consonant structure and prevocalization* (Current Issues in Linguistic Theory 312). Amsterdam: John Benjamins, 2010. *Phonology* 32(2). 307–317. DOI: https://doi.org/10.1017/S0952675715000172

Noguchi, Masaki. 2011. A preliminary study of intonation in Kwak'wala. *University of British Columbia Working Papers in Linguistics* 30. 321–350.

Paramore, Jonathan Charles. 2025. Codas are universally moraic. *Phonology* 42(e1). 1–36. DOI: https://doi.org/10.1017/s0952675724000204

R Core Team. 2026. *R: a language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org/.

Rasin, Ezer. 2018. *Modular interactions in phonology*. Massachusetts Institute of Technology dissertation.

Rosenthall, Sam & van der Hulst, Harry. 1999. Weight-by-position by position. *Natural Language and Linguistic Theory* 17. 499–540. DOI: https://doi.org/10.1023/a:1006283229291

Ryan, Kevin M. 2014. Onsets contribute to syllable weight. Statistical evidence from stress and meter. *Language* 90(2). 309–341. DOI: https://doi.org/10.1353/lan.2014.0029

Ryan, Kevin M. 2019a. Prosodic end-weight reflects phrasal stress. *Natural Language and Linguistic Theory* 37(1). 315–356. DOI: https://doi.org/10.1007/s11049-018-9411-6

Ryan, Kevin M. 2019b. *Prosodic weight: Categories and continua*. Oxford: Oxford University Press. DOI: https://doi.org/10.1093/oso/9780198817949.001.0001

Ryan, Kevin M. & Heath, Jeffrey. 2022. Onset prominence in Wubuy reduplication. In Jurgec, Peter & Duncan, Liisa & Elfner, Emily & Kang, Yoonjung & Kochetov, Alexei & O'Neill, Brittney K. & Ozburn, Avery & Rice, Keren & Sanders, Nathan & Schertz, Jessamyn & Shaftoe, Nate & Sullivan, Lisa (eds.), *Proceedings of the 2021 Annual Meeting on Phonology (AMP)*. Washington, D.C.: Linguistic Society of America. DOI: https://doi.org/10.3765/amp.v9i0.5148

Sayeed, Ollie. 2017. Osthoff's law in Latin. *Indo-European Linguistics* 5. 147–177. DOI: https://doi.org/10.1163/22125892-00501005

Shelton, Michael. 2007. *An experimental approach to syllable weight and stress in Spanish*. The Pennsylvania State University dissertation.

Shelton, Michael & Grant, Hannah. 2018. Syllable weight in monolingual and heritage Spanish. *Studies in Hispanic and Lusophone Linguistics* 11(2). 395–427. DOI: https://doi.org/10.1515/shll-2018-0015

Sherer, Tim. 1994. *Prosodic phonotactics*. University of Massachusetts, Amherst dissertation.

Shih, Shu-Hao. 2016. Sonority-driven stress does not exist. In Hansson, Gunnar Ólafur & Farris-Trimble, Ashley W. & McMullin, Kevin & Pulleyblank, Douglas (eds.), *Supplemental proceedings of the 2015 Annual Meeting on Phonology*. Washington, D.C.: Linguistic Society of America. DOI: https://doi.org/10.3765/amp.v3i0.3666

Shih, Shu-Hao. 2018. On the existence of sonority-driven stress in Gujarati. *Phonology* 35. 327–364. DOI: https://doi.org/10.1017/S0952675718000064

Shih, Shu-Hao & de Lacy, Paul. 2019. Evidence for sonority-driven stress. *Catalan Journal of Linguistics* 18. 9–40. DOI: https://doi.org/10.5565/rev/catjl.256

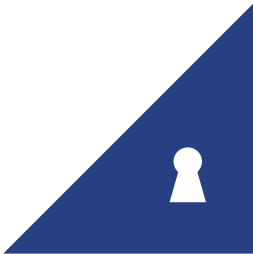
Topintzi, Nina & Zimmermann, Eva. 2025. Reconciling "heavy" and "long": The typology of lexical geminates. *Linguistic Inquiry* 56(2). 311–351. DOI: https://doi.org/10.1162/ling_a_00499

Vaux, Bert & Wolfe, Andrew. 2009. The appendix. In Raimy, Eric & Cairns, Charles E. (eds.), *Contemporary views on architecture and representations in phonology*, 101–135. Cambridge, MA: MIT Press. DOI: https://doi.org/10.7551/mitpress/9780262182706.003.0005

Wetzels, W. Leo. 2007. Primary word stress in Brazilian Portuguese and the weight parameter. *Journal of Portuguese Linguistics* 5. 9–58. DOI: https://doi.org/10.5334/jpl.144

Wilson, Stephen A. 1986. Metrical structure in Wakashan phonology. *Proceedings of the Twelfth Annual Meeting of the Berkeley Linguistics Society*, 283–291. DOI: https://doi.org/10.3765/bls.v12i0.1857

Wolff, Ekkehard. 1983. *A grammar of the Lamang language*. Glückstadt: Verlag J. J. Augustin.

Zec, Draga. 1988. *Sonority constraints on prosodic structure*. Stanford University dissertation. DOI: https://doi.org/10.4324/9780429437168

Zec, Draga. 1995. Sonority constraints on syllable structure. *Phonology* 12(1). 85–129. DOI: https://doi.org/10.1017/S0952675700002396