Word Stress: Phonetic and Phonological Properties and Typology

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Key Points

- Providing a review of the diagnostic dynamic phonetic (allophonic) properties of word stress
- Providing a review of the diagnostic static phonotactic properties of word stress
- Distinguishing different degrees of word stress
- Providing a typology of word stress systems

Abstract

This article reviews the phenomenon of (linguistic) stress as it applies to words. This includes primary stress and nonprimary stress. Firstly, this article provides a discussion of phonetic and phonological (i.e., phonotactic) properties of stress, making a distinction between dynamic allophonic properties that provide cues to stress locations and static, phonotactic asymmetries between stressed and unstressed syllables. Secondly, this article provides typological information about the different types of word stress systems in the languages of the world.

Introduction

In this article, I will discuss the phenomenon of (linguistic) stress as it applies to words. Units that are larger than words (such as phrases and sentences) can be said to have stress too, but I will only briefly touch on these larger units here (see Article 'Phrasal stress'). My goal is to provide insight into the phenomenon of word stress, including phonetic, phonological, and typological aspects.

The Basic Phenomenon

Consider the English word *hippopotamus*. Almost every speaker of English will pronounce the medial syllable of this word with more articulatory force than all other syllables which causes it to be more perceptually salient. It is common to refer to this syllable as being *stressed*. Dictionaries often signal the location of word stress using a specific diacritic symbol, usually before the stressed syllable (*hippo'potamus*), or sometimes they use capitalization of the stressed syllable (*hippoPOtamus*). Another common notation

is to put an 'accent mark' on the stressed syllable (*hippopótamus*). Using the International Phonetic Alphabet, this word would come out as follows: [ˌhɪpəˈpʰɔtəməs].

It is highly typical, for languages that have word stress, for one syllable to stand out above all other syllables, although some of the other syllables can have lower degrees of stress. In English, for example, the first syllable can have what is called secondary stress when the primary stress is further down in the word; this is indicated in the phonetic transcription by a low(ered) vertical line. This leads to distinguishing between primary stress and secondary stress. Here, I will first focus on primary stress before we turn to nonprimary stress, which also involves so-called rhythmic stresses.

Phonetically, articulatory force (which results in a complete realization of the articulatory targets) causes several acoustic properties which the stressed syllable has to a greater degree relative to the other syllables in the word, such as longer duration, greater intensity (perceived as greater loudness) and higher fundamental frequency (perceived as higher pitch). There is usually a change in vowel quality toward a more reduced vowel in unstressed syllables, too. A specific property that has also been mentioned is spectral tilt, which involves an increase of higher frequencies in stressed vowels. While in older literature heightened fundamental frequency (F0, which underlies the perception of higher pitch) was often said to be a main correlate of stress, this turned out to be mostly (but not entirely) due to measuring stressed syllables which are associated to an intonational tone event of some kind (usually a high tone) that is part of the intonational melody; see Sluijter and van Heuven (1996). It is thus necessary to measure acoustic properties of stress in phrasal positions that do not attract such intonational peaks; see Article 'Intonation', and also section **From Stress to Accent** below.

There is considerable cross-linguistic variation in the phonetic properties that signal stress, whether looked at in terms of articulation or acoustics. In a 75-language survey, Roettger and Gordon (2017) find duration to be the most reliable correlate of primary stress. However, other exponents of stress included in their survey (intensity, F0, spectral tilt, as well as vowel reduction) are also predictive of stress (or its absence) in the majority of studies. It should be noted that the term *stress* itself generalizes over a variety of phonetic properties, rather than being a well-defined phonetic concept as such.

Instrumental evidence for nonprimary stress is more difficult to establish. Many descriptions only provide impressionistic reports of nonprimary stresses, which are often unreliable, being influenced by what linguists are used to hear based on their own native language, a phenomenon that Tabain et al. (2014) call *stress ghosting* in their study of Pitjantjatjara [Pama-Nyungan; Australia] in which they found no evidence for secondary word stress that has been reported by nonnative language researchers. De Lacy (2014) discusses other examples that reveal the unreliability of impressionistic reports concerning nonprimary stress. Sometimes, instrumental studies report no cues for primary *or* nonprimary stress even though such stresses have been reported (see, for example: Arnhold et al., 2022 on Inuktitut [Inuit-Yupik; North America]). It should also be mentioned that when stress locations are fully predictable, their phonetic cues are less 'pronounced' which may lead to problems in perceiving or even measuring stress (see Peperkamp et al. 2010), and to claims that there is in fact no stress.

In virtually all instrumental studies in Roettger and Gordon's (2017) survey, secondary stress, if reliably attested, was distinguished from primary stress by only a subset of properties that primary stress displays.

In addition to results of acoustic evidence for stress, support for identifying a syllable as stressed may come from *native speaker intuitions*, which may be accessed either directly through questioning or indirectly through observation of co-speech gestures, such as beat gestures, tapping (i.e., forced tapping of the hand for each stressed syllable), or eyebrow movements, which tend to coincide with stress locations (e.g. Cavé et al. 1996; Leonard & Cummins, 2010; Tuite, 1993).

Cues for stress locations can also come from patterns in song and poetic meter. For example, in the Uto-Aztecan language Tohono O'odham (Fitzgerald, 1998), traditional song meter is sensitive to stress. Although lines in Tohono O'odham songs are highly variable in their number of syllables, they are subject to a restriction against stressed syllables in the second and final positions. See also Moreno and Kabak (2022) for a study of correlations between stress and song in Turkish. For studies of the relation between word stress and poetic meter, see Hayes (1983) and Dresher (2009).

Allophonic and Neutralizing Effects of Stress

The effects of stress can be allophonic or neutralizing (i.e. phonemic). Following traditional practice, an effect is neutralizing if it causes the realization of a phoneme A to be identical to the realization of a phoneme B. In this section, we first discuss allophonic effects of stress. I refer to allophonic effects as dynamic, whereas neutralizing effects are taken to be static in the sense that such effects have been phonologized as phonotactic constraints which can be the cause of allomorphic alternations.[1]

Comparing stressed and unstressed vowels, an overall effect of the enhanced perceptual salience of stressed vowels is their 'full vowel quality' as opposed to a reduced quality of unstressed (or lesser stressed) vowels. Reduced vowel quality can involve allophonic neutralization of vowel contrasts, including reduction to a schwa-like quality, or even deletion (inaudibility) of the unstressed vowel. Deletion is often only a perceptual effect of extreme shortening, and articulatory traces of inaudible vowels may remain (see Gick et al. 2012). Vowel devoicing is another by-product of vowel reduction. For example, in Tongan [Austronesian; Tonga] (Feldman, 1978), an unstressed high vowel devoices when it occurs after a voiceless consonant and either before

[1]This distinction is not without problems because an allophonic process that perceptually appears as neutralizing need not be phonologized as a phonotactic constraint.

another voiceless consonant or utterance finally, e.g. /ˈtuk[i̥]/ 'strike', /ˈtaf[u̥]/ 'light a fire', /ˌpas[i̥]ˈpas[i̥]/ 'applaud' (see Gordon, 1998, pp. 93–105 for a typological study of devoicing). Both vowel reduction and vowel devoicing often parallel deletion in displaying gradience and optionality (or in dependency on style and rate of speech).

A complementary effect to reduction is *strengthening* in stressed syllables (see Bye & de Lacy, 2008 for an overview). For example, short vowels in stressed nonfinal open syllables in Chickasaw [Muskogean; United States] are substantially lengthened (Gordon & Munro, 2007), e.g. /ʧiˌpisaˌliˈtok/ → [ʧiˌpiːsaˌliːˈtok] 'I looked at you', /aˌsabiˌkaˈtok/ → [aˌsaːbiˌkaːˈtok] 'I was sick'.

Another example of strengthening that affects consonants is the lengthening of consonants, i.e., gemination. For example, gemination occurs in Delaware [Algonquian; United States] /nəˈməˑtəmeːˑ/ → [nəˈmətˑtəmeːˑ] (Goddard, 1979: xiii), which in this case creates a closed and thus heavy (stress attracting) syllable (see Article 'Theories of Stress'). Gemination can also apply to a consonant in the onset of a stressed syllable, as in Tukang Besi [Austronesian; Indonesia] (Donohue, 1999) and Urubú Kaapor [Tupi-Guarani; Brazil] (Kakumasu, 1986).

A well-known allophonic effect on the initial consonant of stressed syllables occurs in English. In English, the sound [p^h] (aspirated *p*) is restricted to initial position in stressed syllables (if not preceded by an /s/). In unstressed syllables, instead, the sound [p] is found. In addition, in syllable final position, we always only find [p] (sometimes unreleased [p˺]). The most common analysis is that [p^h] and [p] (and [p˺]) are called *allophones* ('realizations') of one phoneme /p/. The lexical representation of words only has a segment /p/. Since [p^h] only occurs in stressed syllables, its presence is due to an allophonic rule and as such a cue of stress. In a transcription of the word *hippopotamus*, we note that the /p/ of the medial syllable is *aspirated*, unlike the /p/ of the second syllable.

These various manifestations of stress result from phonetic processes that deliver allophonic variations of the segments that make up stressed syllables. Apart from such phonetic correlates stress can also correlate with phonotactic differences between stressed and other syllables, which we turn to now.

A nonallophonic correlate of stress involves the notion of phonemic *contrast*. In languages with stress, regularities in the phonotactic patterns of words can often be broken down into statements about stressed and unstressed syllables (or even in terms of primary, secondary stressed and unstressed syllables). The differences can regard the array of contrastive possibilities for vowels or consonants or the complexity of onsets and rhymes. When such asymmetries exist, unstressed or nonprimary stressed syllables only permit a subset of the vowels and/or consonants, while they may disallow complex (i.e. branching) onsets, nuclei or rhymes. For example, a vowel length contrast is only permitted in stressed syllables in Estonian [Uralic; Estonia] (Harms, 1997). Stress may also be diagnosed through static phonotactic restrictions on tonal contrast as in Trique [Otomanguean; Mexico] (DiCanio, 2008). Certain Bantu languages, often called restricted tone languages, preferentially limit high tone to a single syllable per word (Downing, 2010; Voorhoeve, 1973; van der Hulst to appear a, b), a distribution that is consistent with what we find in canonical stress systems (see section **Definitional Properties and Functions of Stress**). Such distributional restrictions on tone can thus count as a diagnostic of one syllable being privileged, which is then said to have an accent. A common view is that the term *accent* is a general term that applies both to tone or pitch-accent languages and to stress-accent languages (Hyman, 1977); see section **From Stress to Accent**.

While the occurrence of reduced vowels can be an optional allophonic effect, in English, the occurrence of schwa is categorical and thus phonotactically restricted, because unstressed syllables *must* contain a schwa. This can be observed in our previous *hippopotamus* example which might be transcribed phonetically as [ˌhɪpəˈpʰɔtəməs]. The second, fourth, and fifth vowel is [ə], the schwa, a reduced vowel that never occurs in a stressed syllable in English, where we always find the full vowel quality. The occurrence of the full vowel [ɪ] in the first syllable is due to secondary stress. Phonotactic constraints can trigger phonological rules that, for example, replace a full vowel by a schwa in case the vowel in question can occur as stressed or unstressed in different morphological environments. This then causes allomorphic alternations. For example, in English, the word *metal* has initial stress, but in *metallic*, stress is 'shifted' to the penultimate syllable, causing the vowel in the initial syllable to become a schwa while the second vowel acquires its underlying full quality. Whether changes in morphologically related words that relate to stress (or for that matter to other factors) are allophonic or neutralizing (and thus allomorphic) is not always easy to decide (see fn. 1).

Intonational Cues for Word Stress

We have seen that the location of word stress can be cued by various phonetic (allophonic) and phonotactic diagnostics, in addition to speakers' intuitions, experiments and their behavior in song and poetic meter. One further important way in which word stresses can reveal themselves is by functioning as anchoring points for some of the tones that make up the *intonational* melody. An intonational melody in a language like English consists of one or more tones[2] (which can be H, L, or a contour) and additional boundary tones that occur at the beginning or end of the so-called prosodic domain that the melody is associated with (Gussenhoven, 2004; see Article 'Intonation'; and Article 'Prosodic hierarchy'). This domain is usually called the *intonational phrase*, a unit that need not coincide with a syntactic phrase. In English, speakers can draw the listener's attention to specific parts of the utterance (i.e., phrases that are said to be in focus) by associating high tones to certain words in these phrases. In the following simplified example, there are two high tones (H), and no boundary tones are considered. The point here is to see (or hear) that these tones

[2]Following the work of Bolinger (e.g., Bolinger, 1958), these tones as often called 'pitch accents' which is an unfortunate term because we are dealing with phonological tones that link to stressed syllables of specific words in a phrase or sentence.

associate to specific syllables in those words, namely the stressed syllables. Consider the example *hippopotamus* in the following sentence:

(1)
H H
I have always wanted to be a hippopotamus

Thus, we see that intonational tones can be cues of word stress locations in the sense that these tones tell us which syllable in a word has primary stress. If we place the word *hippopotamus* in a sentence in which the speaker does not draw attention to it (for example, because it has already been mentioned before), no H tone will be there to signal word stress, which is now only cued by the inherent properties that were mentioned in section **Allophonic and Neutralizing Effects of Stress** (which may include some elevation of pitch).

Given that intonational tones align with stressed syllables and given that establishing the location of word stress would often be based on considering words in isolation, this would trigger an intonational tone on the stressed syllable. As already mentioned, this long caused the idea that the pitch property of the intonational tone was an inherent property of the stressed syllable. To establish the inherent phonetic properties of stressed syllables, it is thus important to study them in *out-of-focus* positions in which no intonational tone is at play.

The alignment of intonational tones with stressed syllables in languages like English furthermore reveals that in addition to the notion *word stress*, there also is *phrasal stress*. While the last word in the phrase may carry phrasal stress (as is typically the case in Romance languages), this is not necessarily so in all languages, as shown in a Germanic language like Dutch, in which the phrasal stress in a verb phrase falls on the preverbal argument of the phrase final verb. Ladd (2009) shows that other types of phrasal stress systems occur, for example, those in which intonational tones are consistently associated to the first or last syllable in phrases, irrespective of the possible presence of word stress. This article does not discuss phrasal stress rules, which can vary between languages; see Article 'Intonation'.

Considering domains that are larger than words is also relevant for word stress in another way. In some languages, the location of word stress can be relocated in certain phrasal contexts. In English, for example, many adjectival words occur with different stress patterns depending on whether they are placed before a noun or not. The word *thirteen* is finally stressed in isolation or in final positions in phrases, but typically has initial stress in:

(2) thírteen mèn

If the final pattern is taken to be basic, a phrasal adjustment is required due to a rule (often called the *rhythm rule*). There is a rich literature on this phenomenon which occurs in other languages as well. A thorough discussion of many of the relevant facts and analyses can be found in Visch (1999).

Definitional Properties and Functions of Stress

There are certain characteristics associated with 'canonical' stress systems (see Hyman, 2006 for a summary). One of these is the specification of the *syllable* as the bearer of stress, a property termed 'syllable integrity' by Hayes (1995). Syllable integrity precludes stress contrasts between the first and second half of a long vowel or between a syllable nucleus and a coda. Syllable integrity differentiates stress from tone, which is often linked to a subconstituent of the syllable rhyme, called the mora. In other words, the syllable is the *stress-bearing unit*, while the mora may be a typical *tone-bearing unit*. Although syllable integrity is characteristic of most stress systems, this property has been challenged as a universal feature of stress systems; see Gordon and van der Hulst (2020).

Another potentially definitional characteristic of stress is *obligatoriness*, the requirement that every word has *at least* one stressed syllable. Obligatoriness precludes a system in which stress only occurs on certain words but not on others. However, the characteristic of obligatoriness may only apply to major category words (nouns, verbs, etc.) and not to some or all functional words. In English, articles like *the* and *a(n)* are words, but they do not have stress.[3]

One might think that these articles do not have word stress because stress has been characterized as a *relative property* that holds between syllables making up a word (in which one syllable is 'stronger' than the other(s)); see Article 'Theories of stress'. But it is not true that monosyllabic words do not have stress. In English, all words that have at least one full vowel are said to be stressed (on that vowel) and this includes monosyllabic words. Nonstressed functional words will be grouped with adjacent stressed words in so-called clitic groups (see below). Unlike stress systems, restricted tone systems (as well as so-called pitch-accent systems) typically do not require every (major category) word to have tone, although some do; see section **From Stress to Accent**.

[3]Some nonmajor category words like prepositions fall between these two classes of words in terms of their stress behavior.

The complement of obligatoriness is *culminativity*, which requires that every (major category) word has *at most* one syllable with *primary* stress. Most, if not all, stress systems obey culminativity. This statement does not rule out that next to a primary stress, words can have nonprimary stresses.

Obligatoriness and culminativity are not, however, definitional for stress since, as remarked earlier, there are tone languages that require every word to have at least one (usually H) tone and those that only allow a single lexically marked tone per word; see Hyman, 2006; van der Hulst, to appear a, b).

It has also often been suggested that word stresses function as parsing cues, the idea being that listeners can use knowledge of the word stress location to cut up sentences into words. This has been called the *demarcative function* of word stress. For example, if the location of stress is consistently on the first syllable, listeners know that every stress marks the beginning of a new word. From this perspective, it is expected that word stresses always occur on word edges, i.e. on the first or last syllable. But this is not the case. As we will see in section **Ambiguity in What Counts as a Stressed Syllable**, word stresses can occur on nonedge syllables, either invariably (in which case their location can still be a useful cue for finding word edges by making the relevant computations), or subject to variability when syllable weight plays a role. We will also have to reckon with the fact that in some languages, the location of stress is unpredictable (thus lexically marked for each word). In such cases, stress can no longer be said to have a demarcative function and this is also the case for so-called unbounded stress systems in which stress is not necessarily close to the initial or final word edge (see section **Typology of Stress Locations**). What then remains is that word stress still signals the mere number of words in an utterance. Finally, when word stress locations are sensitive to morphological structure (see section **The Domain of Word Stress Can Be Morphological or Prosodic (or Phonological)**), stress locations can function as parsing cues that signal the morphological compositions of words.

Ambiguity in What Counts as a Stressed Syllable

We have seen that the location of stress in English can be signaled by at least the following cues:

(3) *Cues for stress in English*
a. Inherent stretchable allophonic phonetic properties, providing perceptual salience
b. Phonotactic asymmetries between stressed and unstressed syllables
c. Native speaker intuitions
d. Testing, using (for example) tapping experiments
e. The behavior of syllables in song and poetic meter
f. Anchoring of intonational tones

Stress is a once-per-word property (culminativity) and all major category words (and some nonmajor category words) must have stress (obligatoriness). Functionally, stress can mark the boundaries of words when it predictably occurs near to word edges.

Stress is easily identified in its prototypical instantiation in which phonetic and phonotactic exponents, speaker intuitions, and other possible cues converge. There are many languages, however, in which it can be difficult to determine what counts as a stressed syllable because there are contradicting cues. In such cases certain cues that some see as stress cues are attributed by others to the occurrence of intonational tones, including boundary tones that mark edges of prosodic domains (see Gordon, 2014; Roettger & Gordon, 2017 for discussion). Indeed, there are several languages that have traditionally been regarded as stress languages, but that are now generally considered languages in which the perceived prominence arises from phrasal tone marking rather than word-level stress. Examples are French [Indo-European; France] (Jun & Fougeron, 1995), Korean [Koreanic; Korea] (Jun, 1993), Indonesian [Austronesian; Indonesia] (Van Zanten et al., 2003), Ambonese Malay [Austronesian; Indonesia] (Maskikit-Essed & Gussenhoven, 2016), West Greenlandic [Eskimo-Aleut; Greenland] (Arnhold, 2014), and Tashlhiyt [Afro-Asiatic; Morocco] (Roettger et al. 2015). These languages all share 'pitch events' that occur near the edges of domains larger than the word.

There are also languages in which potential correlates of stress do not converge on the same syllable, as in Bantu languages with high tone on the antepenult, but lengthening of the penult (Hyman, 1989) or languages like Belarusian [Indo-European; Belarus] (Borise, 2015; Dubina, 2012) and Welsh [Indo-European; United Kingdom] (Williams, 1983, 1999) with cues to stress spread over the stressed and adjacent syllable.

Predictable and Nonpredictable Stress Locations

When we consider *simplex words* (i.e. words that are not the result of a morphological rule, often a good place to start when investigating word stress), many languages have a fixed location that is determined with respect to the word edge (initial, final, penultimate etc.; see below for details). When languages allow no exceptions to this general rule, one can say that stress is fully predicable or automatic. For example, in Finnish [Uralic; Finland] (Suomi & Ylitalo, 2004) or Icelandic [Indo-European, Europe] (Árnason, 1999), it is always the first syllable that is stressed. This raises the question as to how a phonological analysis of these languages must account for such predictable or so-called *fixed stress*. Traditionally, a phonological analysis distinguishes between sound

properties that are phonemic or contrastive (i.e. the presence or absence of which can distinguish between different 'words') and those that are allophonic. By that criterion stress in Finnish and Icelandic is 'allophonic'. In the lexicon, words do not have to be specified for their stress location, just like allophonic variation of phonemes need not be specified in the lexicon.

However, in some languages, the location of the stressed syllable is not predictable at all, meaning that the location of the stressed syllable in different words (even when identical in their phonemic structure) can differ. In that case we speak of a *free (or lexical) stress system*. For example, in Tagalog [Austronesian; Philippines] (Schachter & Otanes, 1972), words may differ solely on the basis of stress, e.g. /'pito/ 'whistle' versus /pi'to/ 'seven'. We can say that in this language stress is contrastive or phonemic which is exemplified by minimal pairs. In this case, a speaker must memorize the location of stress for each word. This is not so for speakers of Icelandic. They only need to 'memorize' the rule.

In reality, the degree of predictability of the stress location represents more of a continuum than a binary division, since most languages display elements of both contrastive and predictable stress. For example, in Polish, words have predictable stress on the penultimate syllable. However, some words exceptionally have either final or antepenultimate accent (Dogil & Williams, 1999). For another example, consider Spanish in which stress is lexically distinctive, e.g. /'sabana/ 'bed sheet' versus /sa'bana/ 'savannah', albeit stress is confined to a three-syllable window at the right edge. Stress may occur in the final, penultimate or antepenultimate syllable with a strong statistical preference for the penultimate syllable which counts as the default location (cf. Roca, 1999 for a comprehensive account which also reckons with the effects of morphology).

It seems likely that the occurrence of exceptions is restricted in that exceptions do not seem to occur on the opposite edge of where regular stress occurs. This suggests that even in languages that have exceptions, all word stresses are located at the same edge of the word. If such limitations do not appear to exist, we would expect that the languages in question have multiple vocabularies with sets of words that originate from other languages, while maintaining different phonological systems for these lexical strata. In that case, one would have different stress systems coinciding within a single language in which case the term *co-phonology* applies. Another possibility is that the location of stress is sensitive to word classes, with a different pattern in verbs and nouns, for example, which is another instance of co-phonologies.

When whatever the generalization is for simplex words also governs complex words (usually excluding compounds), the language as a whole can be said to have fixed stress (possibly with lexical exceptions for a number of simplex words and even complex words), which differentiates such systems from the above-mentioned lexical, or free, stress systems.

Stress and Morphology

What then is the domain of word stress? Typological studies of stress locations often assume that locations, if predictable, are the same for all words, whether morphologically simplex or complex. This may indeed be the case (as for example in Polish, where stress is predictably in penultimate position in all words, allowing for some exceptions). However, in many languages, morphological structure plays a role in determining the stress location. This can happen in several ways. One possibility is that stress is predictable within a certain morphological subdomain that is smaller than the whole word, such as the root or stem (however defined), with affixes being added that have no effect (which would then be called *stress-neutral*).

It can also be that only a subclass of the affixes falls within the scope of the stress rule. In this case, the stress rule must be applied after these affixes have been added (which would then be called *stress-sensitive*). A possibility is in this case that the stress rule first applies to the innermost root or stem and subsequently again each time after an affix is added. This procedure is called *cyclical assignment* of stress. Stresses of embedded *cycles* may survive as nonprimary stresses. However, predicted cyclic nonprimary stresses do not always show up where they are supposed to. There can be rhythmic adjustments. English has been subject to numerous studies of its word stress system with details about the impact of different kinds of affixes and the notion of cyclicity. For a comprehensive account, see Kager (1989).

In some languages, specific affixes may be lexically stressed (called *stress-bearing* affixes) in which case it can happen that several morphemes that co-occur in a complex word will compete for primary stress. Such competition can be resolved in two ways (Bogomolets, 2020; Bogomolets & van der Hulst, 2022). A linear strategy is to designate the first or last stress as the winner, while the other, hierarchical, strategy considers the morphological structure and selects, for example, the last added affix as the winner (which can often also be analyzed in linear terms), or ranks an inflectional affix over a derivational affix; see Revithiadou (1998) for case studies of hierarchical systems. In both types of systems, a default stress rule is needed when a word contains no morpheme that has lexical stress. Much is still unknown or unclear concerning the roles of linear or hierarchical resolution, especially in languages of the polysynthetic type, in which we find words composed of many morphemes; for such cases and more broadly for the role of morphology in stress, see Bogomolets and van der Hulst (2022) for many case studies and van der Hulst (2022) for a general discussion.

Another case occurs when certain affixes 'refuse' to be stressed. For example, *stress-rejecting affixes* in Kabardian [Northwest Caucasian; Russia] (Gordon & Applebaum, 2010) create deviations from the otherwise predictable stress pattern, e.g., predictable penultimate stress in /'məʃɐ/ 'bear' versus final stress in /mə'ʃɐ/ 'this milk' attributed to the stress-rejecting prefix /mə-/ 'this'.

Finally, in some languages, specific affixes may be associated with rules that, for example, place the word stress on the syllable preceding them (*prestressing affixes*) or even on the first syllable of their base; see Dąbkowski (2021) for a case study.[4]

A special case of complex words is *compounds*, the parts of which usually form independent domains for word stress. When a binary compound is formed, the two stress locations are then differentiated in terms of a *compound stress rule* that gives primary *compound stress* to one of the compound parts. In English and Dutch, primary compound stress goes to the leftmost constituent of the compound, but there are many special cases. In English, for example, the rightmost member wins if it is itself a compound:

(4)	[[kitchen] [towel rack]]

Word stresses that are not thus selected can then survive in the prominence structure of compounds as nonprimary stresses. The compound stress rule thus applies cyclically at every level of complex compounds, from bottom to top, thus creating a number of nonprimary stresses that can be perceptually differentiated depending on the depth of embedding, although due to rhythmic adjustments secondary stresses in compounds can occur in noncyclic locations; see Visch (1999). Different languages can have different rules for compound stress; I am not aware of a typological study, but information about compound stress in European languages can be found in Finkbeiner and Schlücker (2019).

Morphology can also play a different role in stress location. Consider the following pairs of English words:

(5)	convíct	cónvict
	objéct	óbject
	protést	prótest
	permít	pérmit
	pervért	pérvert

If one pronounces these words, pairwise, one will notice a difference that seems to involve the (relative) prominence of the syllables that the words are composed of. In this case, word class (verb vs. noun) is involved in the stress location of these words, which means that the stress rule that accounts for the difference can be called a morphological rule, or a phonological one that is associated with the morphological process of *conversion*.

The Domain of Word Stress Can Be Morphological or Prosodic (or Phonological)

While the discussion thus far implicitly assumes that the domains of stress are *morphological words* (i.e. morphologically simplex or complex words), it has also been claimed that the domain, in general or in specific languages, is the *prosodic word*, given a phonological theory that distinguishes a morphosyntactic hierarchical structure from a so-called prosodic hierarchical structure (see Article 'Prosodic Hierarchy'). Distinguishing two planes that are or may be providing domains for phonology raises the question which one is being referred to by any given phonological rule or generalization. There is a rich literature that addresses this question, and the majority consensus is that there are in fact two types of phonology that co-exist. Rules that reflect sensitivity to lexical or morphosyntactic properties must refer to the *morphosyntactic structure*, while rules that lack such sensitivity refer to the *prosodic structure*. Prosodically based rules have various characteristics that Kiparsky (1985) identifies for rules that he calls *post-lexical*. How the morphosyntactic and prosodic hierarchy relate to each other is a topic of continuing research (see Nespor & Vogel, 1986 for the classical reference and Article 'Prosodic Hierarchy').

Given the distinction between these two types of rules, one possibility is that in languages that have completely predictable, so-called automatic stress, reference is made to a prosodic domain, such as the *prosodic word*. A prosodic word is a domain that may coincide with the entire morphological word, or with a morphological subdomain of it or it may comprise more than one word. Much depends on one's treatment of inflection which, if dealt with syntactically, may necessitate an 'extended' prosodic word domain for inflected words that is larger than the prosodic domain for simplex words and complex words with derivational affixes. This suggests that the prosodic word may be a recursive domain. In those cases where stress placement has been argued to refer to a prosodic word domain that appears to be larger than the morphosyntactic word, a special case involves what are called *clitics* (see Article 'Prosodic Hierarchy'), which are separate syntactic units (i.e. functional words) that lack word stress and thus are incorporated into the prosodic structure of a preceding or following syntactic word, forming a *clitic group* (which some regard as a recursive version of the prosodic word); cf. Peperkamp (1997) for extensive discussion, with specific reference to Italian clitics. In some languages, clitics may come with the requirement that stress must occur on the syllable preceding them, as the Latin clitic *-que* 'and'. In a language like English, an extended prosodic word arises when functional words cliticize to major category words which

[4]While not a stress-accent language, Poser (1984) discusses several such rules in Japanese, a pitch-accent language. Sanskrit is another language that exemplifies such special accentual rules; see Kiparsky (1984).

may trigger specific processes, although no specific stress rules in this language; cf. *(he's) (home)* or *(the boy) (is playing) (soccer)* witch each parenthesized unit forming a prosodic word.

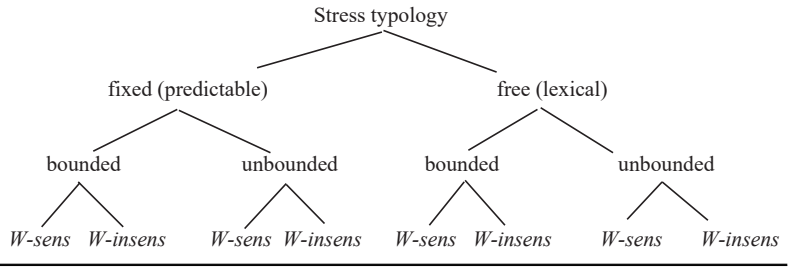
Typology of Stress Locations

Stress is widespread in languages of the world. Of the 176 languages included in the 200-language World Atlas of Linguistic Structures (WALS) sample, approximately 80% (141 languages) are reported to have stress (see Goedemans and van der Hulst 2015a-d)[5]. Tone and stress have sometimes been regarded as mutually exclusive. However, an increasing body of research has demonstrated cases of stress and tone co-existing in the same language, either functioning orthogonally to each other or being predictive from tone to stress or the other way around. I refer to De Lacy (2002), for an overview.

There are many typological surveys of word stress systems (e.g., Greenberg & Kaschube, 1978; Hyman, 1977; Hayes, 1995; Bailey, 1995; Gordon, 2002; Goedemans and van der Hulst 2015a-d). I here summarize some of the results of this type of work. This will lead us to making several distinctions that have only been mentioned in passing thus far, such as whether stress location is sensitive to properties of syllables (*weight-sensitivity*) and whether the domain of stress is *bounded* (comprising a 2- or 3-syllable window) or *unbounded* (comprising the whole word, however defined).[6]

Surveys reveal languages with predictable locations of stress, which has been called fixed stress in this article. Note that here 'fixed' means that stress is predictable *on phonological grounds* and not that stress is always on the same syllable in every word. Fixed stress can mean that the location of predictable stress is dependent on syllable weight in which case the location will here be called *variable*. When the stress location is not sensitive to syllable weight, it is here called *invariable*. When stress is not fixed (i.e., not predictable), but instead differs from word to word, stress is called *free* or *lexical*. We will also see that the stress location (whether fixed or free) can be limited to a small domain at the left or right edge of the word, in which case we speak of *bounded* systems. If such a limitation does not hold, a system is called *unbounded* (in which case stress may be predictable/fixed or free/lexical).

(6)



We first focus on fixed bounded weight-insensitive (invariable) stress.

(7) Initial stress: Icelandic [Indo-European, Europe]; Árnason (1999)
Second syllable stress: Dakota [Siouan, North America]; Shaw (1976)
Third syllable stress: Ho-chunk [Siouan; United States]; Hayes (1995)
Antepenultimate stress: Macedonian [Slavic, Europe]; Franks (1987)
Penultimate stress: Polish [Slavic, Europe]; Dogil (1979)
Final stress: Weri [Trans-New Guinea, Papua New Guinea]; Boxwell and Boxwell (1966)

A rich source of information about these and many other stress systems, containing references and many detailed analyses, remains Hayes (1995). Third syllable stress has long been contested, and it does seem rare, but convincing cases have now been reported. See, for example, the case of Ho-chunk [Siouan; United States]. Third syllable stress is more common as the *default pattern* in certain languages with lexical stress, e.g., Azkoitia Basque [isolate; Spain] (Hualde, 1998). We can conclude that there are six possible locations for bounded, invariable fixed stress. This suggests six possible bounded stress locations:

(8) [σ σ σ … σ σ σ]

[5]Published in: Haspelmath, Martin, Matthew S. Dryer, David Gil and Bernard Comrie (eds.) *The World Atlas of Language Structures Online*. Munich: Max Planck Digital Library, chapter 39. Available online at http://wals.info/feature/39.

[6]For overviews and analyses of stress systems in European languages, see van der Hulst (1999). For a broader perspective on word prosodic systems in the language of the world, see van der Hulst, Goedemans, & van Zanten (2010). For analyses of word prosodic systems in a number of polysynthetic languages, see Bogomolets and van der Hulst (2022). A database, built by Rob Goedemans, Harry van der Hulst, and Jeff Heinz, currently containing information about the word stress in 800 languages, StressTyp, is available at: http://st2.ullet.net/.

Three stress locations (initial, penultimate, and final) statistically predominate, as illustrated in Fig. 1 based on the StressTyp2 (Goedemans and van der Hulst, 2015a,b,c,d) database of 699 languages which does not contain enough languages with third syllable stress to be included:

Stanton (2016) hypothesizes that the absence of languages that orient stress toward the middle of the word rather than an edge, the 'midpoint pathology', is attributed to the difficulty in learning such a pattern due to the relative rarity of words of sufficient length to disambiguate mid-point stress from other potential analyses available to the language learner.

We have so far considered cases in which stress is invariably fixed on a specific syllable location in all words (barring exceptions and ignoring the impact of morphology). However, in some languages, certain types of syllables (called *heavy*) 'demand to be stressed' which causes the stress location to be variable, albeit still fixed (in the sense of predictable). This is called *weight-sensitivity*. The 'weight' of a syllable is determined by its intrinsic, phonological properties. There are various factors that play a role in weight, which is typically a binary distinction (but see below), i.e., languages will split the set of syllables into two sets, one called 'heavy', the other called 'light':

(9)	*heavy*	*light*
	long vowel	short vowel
	closed syllable	open syllable
	full vowel	reduced vowel
	low vowel	non-low vowel
	high-toned vowel	low-toned vowel

The first two types have also been called *moraic weight*, assuming that in each of these cases the heavy syllables contain two units in their syllable rhyme; these units are called moras (or weight-units). Such systems are said to have *quantity sensitivity*. Many languages thus treat syllables with long vowels (CVV) as heavier than those with short vowels, while others preferentially treat *both* CVV and closed syllables (CVC) as heavy. To treat CVC as heavy and CVV as light is uncommon. The case of Dutch might be an example (see Lahiri & Koreman, 1988), although van der Hulst (1984) explains that the alleged CVV syllables are actually CV syllables. In the remaining three cases (for which we might adopt the term 'sonority weight' or 'prominence-driven weight'; cf. Kenstowicz, 1997), the heavy syllable is more salient by virtue of its nonreduced articulation, its greater aperture, or its carrying a high tone. These cases can also be called *quality sensitive*; see, however, Shih (2016, 2018) and Rasin (2016) for the paucity of compelling evidence for vowel quality-based stress. Intuitively, it may seem clear that all the properties in the left-hand column give more prominence to a syllable (or its rhyme) in terms of duration (long vowel, closed syllables), or precisely those factors that can be found as phonetic cues of stress. It seems obvious that syllables that have more of those properties are reluctant to appear in positions that typically have less of them, i.e., unstressed positions. Conversely, syllables with such intrinsic properties will "attract" stress. Even though in weight-sensitive systems stress placement is predictable by rule, the stress location is called variable because it varies due to the influence of the content of the syllables that are within the scope of the stress rule. Overall, it is more

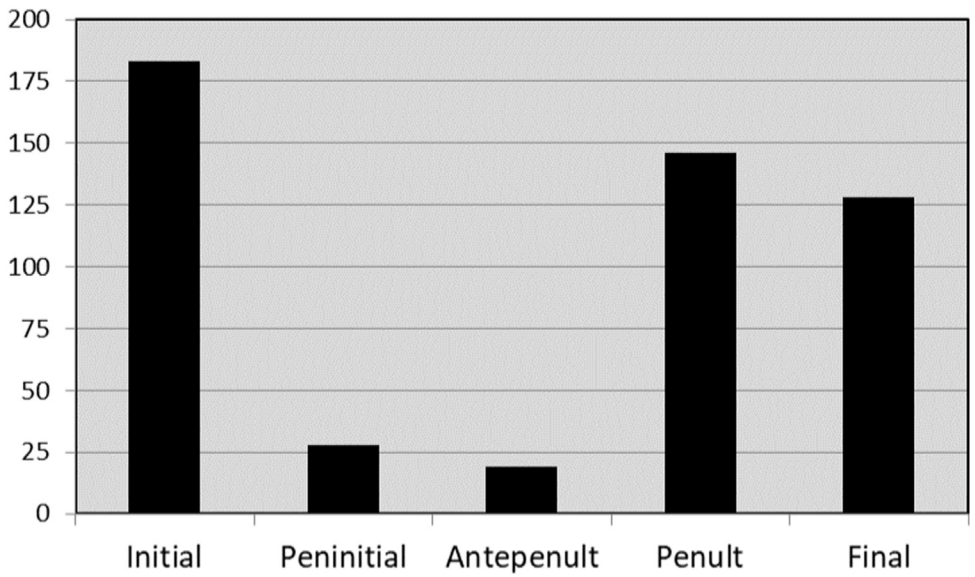


Fig. 1 Number of languages with different fixed stress locations according to StressTyp2 (Goedemans & van der Hulst, 2009).

common for a weight-sensitive stress system to be sensitive to the structure of the syllable rhyme than to vowel quality or tone (see Gordon, 2006 for statistics).

In some languages, weight is scalar (Gordon, 2006; Hayes, 1995), and in others, weight is said to be sensitive to onset consonants (Gordon, 2005; Topintzi, 2010). Pirahã [Mura-Pirahã; Brazil] (Everett & Everett, 1984; Everett, 1998) observes a scalar weight hierarchy that simultaneously appeals to both rhymal weight and onset 'weight': stress falls on the rightmost heaviest syllable within a three-syllable 'window' at the right edge of a word. The Pirahã weight scale is KVV > GVV > VV > KV > GV, where K stands for a voiceless onset and G for a voiced onset. Onset-sensitive weight is rare compared to rhyme-sensitive weight. Of 136 languages with weight-sensitive stress in Gordon's (2006) survey, only four involve onset-sensitivity (either presence vs. absence or type of onset). The primacy of rhymal weight is mirrored language internally: onset weight almost always implies rhymal weight and where the two co-exist, rhymal weight takes priority over onset weight. This dependency is exemplified in Pirahã, where a heavier rhyme (one consisting of a long vowel) outweighs a heavier onset (one containing a voiceless consonant), i.e. GVV outweighs KV. See Everett and Everett (1984), Goedemans (1998), Gordon (2005) and Ryan (2014).

Many other languages display the effect of *syllable weight* (cf. Goedemans, 1998; Hyman, 1985). Here are two examples:

(10) Rotuman [Austronesian; Fiji]: Primary stress falls on the final syllable if this syllable contains a long vowel, otherwise it falls on the penultimate syllable (Churchward, 1940, p. 75)
Yapese [Austronesian; Micronesia]: Primary stress falls on the penultimate syllable if the final is closed and the penultimate is open, otherwise it falls on the final syllable (Hayes, 1980, pp. 65–66)

English word stress, which occurs on the right word-edge, is clearly bounded and weight-sensitive (in addition to being governed by a substantial number of lexical exceptions); cf. Kager (1989) for a detailed treatment.

The way in which stress location can be sensitive to the internal structure or 'weight' of syllables is also reflected by the fact that light syllables may specifically reject stress. For example, in Piuma Paiwan [Austronesian; Taiwan] (Chen, 2009), stress typically falls on the penultimate syllable of a word: /ku'vuvu/ 'my grandparents', /səmu'kava/ 'to take off clothes'. However, if the penult contains a light syllable, one containing a schwa, stress migrates rightward to the final syllable (even if it, too, contains schwa): /qapə'du/ 'gall', /ʎisə'qəs/ 'nit'.

In the systems with predictable stress (whether weight-sensitive or not) discussed thus far, stress is limited, or *bounded*, to a range of two or three syllables at a word edge, which is called the *stress window*.

Free (lexical) stress may also be limited to a bounded stress window. For example, Choguita Rarámuri [Uto-Aztecan; Mexico] (Caballero & Carroll, 2015) has lexically contrastive stress operative within a three-syllable window at the left edge of a word, with the most frequent stress location (often called the default location) being the second syllable: /'humisi/ 'run away PL' versus /a'sisi/ 'get up' versus /bini'hi/ 'accuse'. When a lexically stressed suffix attaches to a root with default second-syllable stress, stress is shifted to the suffix unless it were to fall outside the left-edge three-syllable window. For example, the conditional suffix /sa/ attracts stress in /ru-'sa/, 's/he is saying' and /ʧapi-'sa/ 's/he is grabbing', but not in /ruru'wa-sa/ 's/he is throwing liquid'.

Not all stress systems are bounded. For example, stress in Yana [isolate; California] (Sapir & Swadesh, 1960) is 'unbounded', falling on the leftmost heavy syllable (CVV or CVC) regardless of its position in a word. In words lacking a heavy syllable, stress defaults to the initial syllable. Languages like Kʷakʼʷala [Wakashan; Canada] differ minimally from Yana in that stress defaults to the last syllable if there are no heavy syllables in the word (Bach, 1975). In fact, there are four basic types of weight-sensitive unbounded systems:

(11) Unbounded systems

a. RIGHT/LEFT: Sikaritai [Lakes Plain language of Papua] Martin (1991)
Primary stress falls on the RIGHTmost heavy syllable. Default: if there is no heavy syllable, primary stress falls on the LEFTmost syllable

b. LEFT/RIGHT; Kʷakʼʷala [Wakashan; Canada]
Primary stress falls on the LEFTmost heavy syllable. Default: if there is no heavy syllable, primary stress falls on the RIGHTmost syllable

c. RIGHT/RIGHT: Puluwatese [Austronesian; Poluwat, Micronesia] Elbert (1974)
Primary stress falls on the RIGHTmost heavy syllable. Default: if there is no heavy syllable, primary stress falls on the RIGHTmost syllable

d. LEFT/LEFT: Yana [isolate; California]
Primary stress falls on the LEFTmost heavy syllable. Default: if there is no heavy syllable, primary stress falls on the LEFTmost syllable

All examples in (11) show weight sensitivity. This leads to the question what a weight-insensitive unbounded system would look like. Clearly such cases would have fixed peripheral stress which makes them hard to distinguish from a bounded weight-insensitive

system. For discussion, see van der Hulst (1999) with reference to Turkish which has final predictable invariable final stress, but certain exceptional patterns reveal that the system is in fact unbounded. Also see: Inkelas and Orgun (2003).

Unbounded systems may also have stress locations that are not phonologically predictable in the manner in which the stress location is predictable in the systems in (11). If, in languages with unbounded stress, several morphemes with lexical stress are combined into a complex word, the leftmost or rightmost among them will attract stress. A case in point is Russian [Indo-European; Russia], in which primary stress falls on the rightmost syllable with diacritic weight and on the first syllable (the default case) if there is no syllable with diacritic weight: /gospo'ʒa/ 'lady', /ko'rova/ 'cow' versus /'zʲerkalo/ 'mirror', /'porox/ 'powder' (Halle, 1973).

Lexical Exceptions and Diacritic Weight

Returning now to the phenomenon of lexical exceptions, van der Hulst (1999) suggests that syllables with lexical stress marking display what might be called *diacritic weight*. For example, in the Russian case just cited, lexically marked stress in morphemes acts just like heavy syllables do. One might then ask whether phonological weight or diacritic weight prevails when both occur together within the same language. I refer to Vaxman (2016, 2019) for discussion and relevant examples.

NonFinality

Many stress systems, whether bounded or unbounded, exhibit a bias against (primary or secondary) stress on final syllables. Final stress avoidance has different manifestations. In Latin [Romance; Mester, 1994], stress is antepenultimate or penultimate depending on the weight of the penultimate syllable, but it is never on the final syllable, whatever its weight. It is apparently the case that to establish the right-edge stress window, the rightmost syllable of words can be 'ignored'. In so-called metrical theories of stress (see Article 'Theories of stress'), this effect is called *extrametricality*.

Another example of nonfinality can be seen in languages that have stress on the second syllable of a word, but not if that stress would be final. For example, in Hopi [Uto-Aztecan, United States] (Jeanne, 1982), stress falls on the second syllable of a word with more than the two syllables if the first syllable is light, but in disyllabic words stress is initial regardless of the weight of the first syllable: /kɨ'japi/ 'dipper', /la'qana/ 'squirrel', /'koho/ 'wood', /'maqa/ 'to give'.

Another species of nonfinality occurs in weight-sensitive systems in which final weight criteria are more stringent than in nonfinal syllables. Thus, in Cairene Arabic [Afro-Asiatic; Egypt] (Mitchell, 1960), CVC attracts stress in the penult, as in /mu'darris/ 'teacher M.SG.', but a final syllable containing a short vowel must have two coda consonants to attract stress, cf. /xa'biːr/ 'specialist', but /'asxan/ 'hotter' (see Rosenthall & van der Hulst, 1999 for more on context-driven weight for stress).

Lunden (2010, 2013) offers an account of nonfinality based on differences in the relative phonetic duration of syllables in final versus nonfinal syllables.

If nonfinality is to replace the older notion of extrametricality, this would suggest that initial extrametricality does not occur. This is debatable because languages that assign stress with reference to a three-syllable window on the left edge may have initial syllable extrametricality if stress never falls on the first syllable.

Primary and Nonprimary Stress

Students of stress have long noticed that languages with word stress may exhibit prominence patterns that go beyond primary stress. In the word *hippopotamus*, for example, the first syllable is noticeably stronger than the second. Indeed, in English at least, the first syllable of words is typically 'strong', especially when the second syllable does not carry the primary stress. This initial strength has been called *secondary stress*. In words that are long enough, one can even encounter more than one nonprimary stress as in *Apalachicola*, which has a strong syllable in first, third and fifth position. The latter forms the primary stress. Between the first and third syllable, linguists notice a strength difference such that the first syllable is stronger than the third. The third syllable apparently carries a *tertiary stress*. The claim that the first and third syllable have a degree of stress is justified because those syllables have a full vowel, rather than a schwa, and this is here taken as a cue of stress. Recognizing all stresses is thus relevant in that, at least in English, the occurrence of the schwa-vowel is directly determined by stress: full vowels can only, and must, occur in syllables that bear some degree of stress. Intervening unstressed syllables can only contain the vowel *schwa* (or sometimes somewhat 'colored' *reduced vowels* such as [ɪ] or [ʊ] (as in *happy* and *widow*). In general, in other languages, nonprimary stresses may display other cues such as the ones we mentioned for primary stress like extra duration, aspiration, or certain phonotactic complexities. A complete account of word stress, then, must reckon with all stresses at the word level.

In some languages, there may be a single secondary stress at the opposite edge from the primary stress. For example, in Savosavo [Central Solomon Papuan; Solomon Islands] (Wegener, 2012), primary stress typically falls on the penult with secondary stress on the initial syllable, as in /ˌsi'noqo/ 'cork', /ˌkena'ɯuli/ 'fishing hook'. van der Hulst (1996) refers to such systems as having *polar secondary stress*. English does not only show the effect of a polar secondary stress, but also of what is called rhythmic secondary stress. However, languages that have rhythmic stresses do not necessarily display the polar stress effect. Languages with a fixed primary and a single fixed secondary polar stress are relatively rare compared to those with (additional) rhythmic stress. In Gordon's (2002) survey of 262 quantity-insensitive languages, only 15 feature a single secondary stress compared to 42 with rhythmic secondary

stress. Both, though, are considerably rarer than single fixed stress systems which have no nonprimary stresses at all, which number 198 in Gordon's survey, though it is conceivable that some languages for which only primary stress is described may turn out to have secondary stress, given that descriptive reports on non-primary stress are often missing. Here we must also recall that if nonprimary stresses *are* mentioned, the reports may not always be reliable.

While rhythm is usually binary, creating an alternating 'strong–weak–strong–weak' pattern with a beat on every other syllable, in some systems rhythm appears to be ternary which creates a 'strong–weak–weak–strong–weak–weak' pattern. A case in point is Cayuvava [isolate; Bolivia] (Key, 1961, 1967) in which primary stress falls on the antepenultimate syllable and secondary stress falls on every third syllable to the left of the primary stress: /iki,tapare'repeha/ 'the water is clean', /,ʧa.adi,roboβu'uruʧe/ 'ninety-five (first digit)'. StressTyp2 (Goedemans & van der Hulst, 2009) cites only two weight-insensitive stress systems with stress on every third syllable, although there are a few weight-sensitive stress languages in which ternary intervals occur in sequences of light syllables (see Hayes, 1995).

As shown in Hayes (1995), the rhythmic patterns of words display a rich crosslinguistic variation which has led to distinguishing trochaic from iambic rhythms, along with binary from ternary rhythms.

Nonfinality can play a role with respect to rhythm. Some languages suppress or shift a rhythmic secondary stress that would be predicted to fall on a final syllable. An example of final stress suppression comes from Pite Saami [Uralic; Sweden] (Wilbur, 2014), which has the same basic rhythmic stress pattern as Tohono O'odham except that final odd-numbered syllables are not stressed, e.g., /'saːlpma,kirːje/ 'psalm book NOM.SG', /'kuhka,jolkikijt/ 'long-leg-NMLZ-ACC.PL'.

Stanton's (2016) survey of word length in 102 languages suggests, as one might expect, that rhythmic stress (generalized over all subtypes) is especially prevalent in languages with longer words, whereas single stress systems are more common in languages with fewer long words. **Fig. 2** plots the median percentage of words ranging from one to four-or-more syllables for languages with a single stress per word (34 languages in her database) and for those with rhythmic secondary stress (22 languages). Nonstress languages and those with other types of stress systems, like those based on tone or those with one stress near each edge of the word, are excluded in the figure.

The two sets of languages display virtually identical frequency patterns for words with two and three syllables but differ in the relative frequency of monosyllabic words and words of at least four syllables. Monosyllables vastly outnumber (by nearly 30%) words with four or more syllables in the single stress languages but are only marginally more numerous than long words in the languages with rhythmic stress. This asymmetry suggests that stressless sequences of syllables (co-called *stress lapses*) are dispreferred and that when the morphology of a language creates longer words in sufficient frequency, speakers tend to impose rhythmic stress patterns, which may then generalize to shorter words.

When primary stress and rhythmic stresses co-occur, the rhythmic 'wave' typically starts at the edge of the primary stress, assigning a 'beat' to the syllable that is one syllable removed from the primary stress and then proceeding leftward in an alternating fashion. For example, primary stress in South Conchucos Quechua [Quechuan; Peru] (Hintz, 2006) falls on the penult, with secondary polar stress docking on the initial syllable. The rhythmic pattern that is assigned *in between* the primary and polar stress puts stress on alternating syllables to the left of the penult, as in /,waˌraːkaˌmunqa'naʧi/ 'I crunch up my own (e.g. prey) with teeth'. English has been analyzed in the same way. However, it has been argued that sometimes it would seem that the rhythmic wave starts from the edge of the polar stress, or simply, in the absence of polar stress, on the site that is opposite to where the primary stress is.

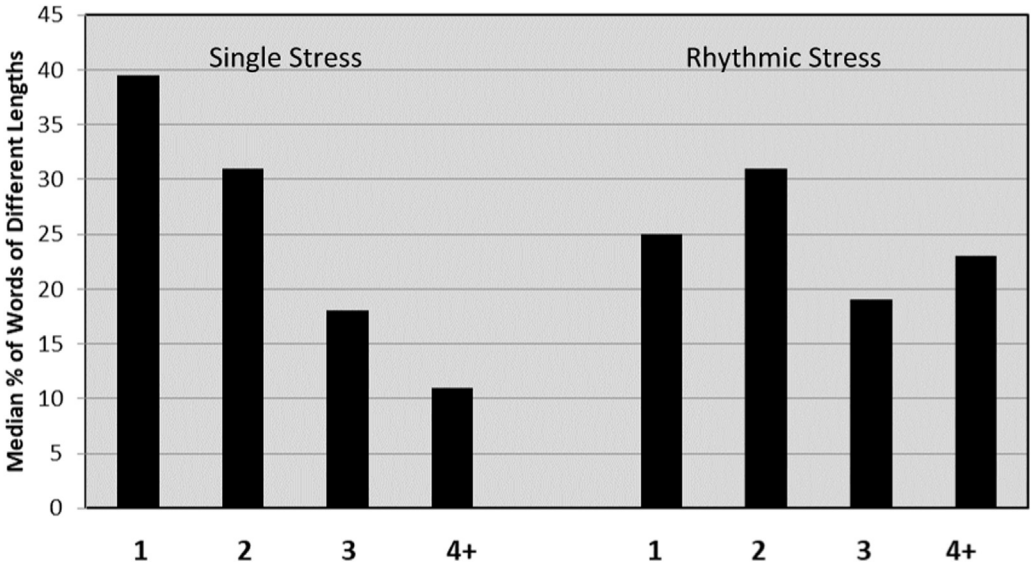


Fig. 2 Median percentage of words with differing numbers of syllables in languages with a single stress per word and those with rhythmic secondary stress in Stanton (2016).

This 'bidirectional' nature of stress can lead to adjacent stresses (i.e., stress clashes) in words with an odd number of syllables which are usually avoided. For example, in some bidirectional systems, like Garawa [Australian; Australia] (Furby, 1974, pp. 1–11), rhythmic stress is suppressed where it would result in a stress clash. Such systems have been called *bidirectional* which here means that rhythm does not depart from the primary stress edge. However, in the absence of very long words, it may be hard to determine from which edge the rhythmic wave is coming.

Nevertheless, a recurring feature of languages with rhythmic stress is to not be bidirectional, which means that the primary stress usually seems to serve as the starting point for the placement of rhythmic stresses (van der Hulst, 1984). Thus, in a language with rightward propagation of rhythmic stress, e.g., Tohono O'odham, the primary stress is the leftmost stress, whereas in languages with leftward iteration of rhythmic stress, e.g., Émérillon [Tupian; French Guiana] (Gordon & Rose, 2006) and Cayuvava [isolate; Bolivia] (Key, 1961, 1967), the rightmost stress is the primary one.

In systems in which primary stress is the starting point for rhythmic stress, one could argue that primary stress is assigned first with rhythmic stress being assigned afterward. This possibility forms the basis for the 'primary stress first' approach developed in van der Hulst (1984, 1996; van der Hulst and Goedemans, 2014; see Article 'Theories of stress').

(12) Primary stress > rhythmic stress

We should note that the so-called bidirectional systems in which rhythm starts at the edge that is opposite to the edge of the primary stress, do not necessarily contradict the primary stress first approach. When polar stress is at play, no order can be established between primary stress and polar stress but van der Hulst provides arguments for ordering polar stress after primary stress because the former displays the same automaticity that rhythm displays. In contrast, primary stress, even when highly predictable, is often subject to lexical factors. Van der Hulst also suggests that polar stress precedes rhythmic stress because in bidirectional systems the latter can depart from the former if both are present.

Systems in which the primary stress must follow rhythmic stress, because the location of the former appears to be dependent on the rhythmic pattern that is established first, are comparatively rare. A case in which a leftward rhythmic strong-weak pattern must precede assigning primary stress is found in Malakmalak [Australian; Australia] (Birk, 1976). In this language, suppressing details, primary stress is initial in words that have an odd number of syllables and on the second syllable when the number of syllables is even. This can only be explained if the syllables are grouped in a strong–weak pattern starting at the right edge. Without assigning rhythm first, there is no way to explain the two primary stress locations:

(13) a. s w s w s w s w
σ σ σ σ σ σ σ σ
b. w s w s w s w
σ σ σ σ σ σ σ

Van der Hulst calls such systems *count systems*. It has been argued that the alleged primary stress in such cases may plausibly reflect phrasal tone rather than word stress (van der Hulst, 1997; Gordon, 2014).

A detailed account of rhythmic patterns that have been claimed to exist in many languages can be found in van der Hulst (2014), here bearing in mind that reports on rhythmic patterns must be treated with caution.

From Stress to Accent

While many languages display the phenomenon of word stress as here described, many other languages display a quite similar phenomenon in that a particular syllable in the word is singled out, the difference being that the cues for its special status are not the same phonetic, allophonic and phonotactic cues that we find in languages like English. In one specific case that is often mentioned, the syllable that stands out is mainly or perhaps exclusively associated with a high(er) pitch. The typical example is (Tokyo) Japanese in which words have pitch patterns that involve a high pitch on what is called the *accented* syllable (in addition, there is leftward spreading of this high pitch); McCawley (1968), Haraguchi (1977). Hyman (1977) referred to such systems as *pitch-accent systems*, while proposing to use the term *stress-accent systems* for cases like English. (An older terminology speaks of 'musical' accent and 'dynamic accent', respectively.) In this terminological proposal, the term 'accent' refers to the property of 'being the privileged location for something', while the terms 'stress' and 'pitch' refer to the phonetic cues that perceptually signal the location of the privileged syllable. It is conceivable that a fine-grained typology of cues for word accent will reveal many more types such as duration-accent systems (in which duration is the primary or only cue which may actually be the case in many stress-accent languages). It would seem that in such a typology, the term 'stress' refers to a rather heterogeneous collection of phonetic, allophonic and phonotactic properties. It may be that such a collection of properties represents a true type, but it may be that, on closer investigation, so-called pitch-accent languages may also involve additional allophonic and phonotactic cues. In short, accent may be signaled in terms of many combinations of cues of various sorts. The cross-linguistic array of accentual cues is at present far from

understood and much detailed phonetic and phonological analysis is needed in this respect; cf. Dogil and Williams (1999) and Roettger and Gordon (2017). The important point here is that it seems useful to separate the notion *accent* (a formal property of syllables without any link to specific cues) and the accentual cue(s) that reveal the location of the accent, cf. McCawley (1968).

Conclusions

The study of word stress forms a rich area of phonological typological research that continues to inspire the formulation of new theoretical approaches and is thus in the forefront of the continuing development of phonological theory (see Article 'Theoretical approaches to word stress'). Firstly, this article has provided a discussion of phonetic and phonological (i.e. phonotactic) properties of stress, making a distinction between dynamic allophonic properties that provide cues to stress locations and static, phonotactic asymmetries between stressed and unstressed syllables. Secondly, the article provided typological information about the different types of word stress systems in the languages of the world, covering both primary and nonprimary stress locations.

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