Chapter 5
Word Stress

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5.1 Introduction

Stress refers to increased prominence on one or more syllables in a word.[1] Depending on the language, stress is diagnosed in different ways: through a combination of physical properties, speaker intuitions, and phonological properties such as segmental constraints and processes. For example, the first syllable, the stressed one, in the English word *totem* /ˈtoʊtəm/ is longer, louder, and realized with higher pitch than the unstressed second syllable. In addition, the /t/ in the stressed syllable is aspirated, while the unstressed vowel is reduced to schwa and the preceding /t/ is flapped. It is possible for a word to have one or more secondary stresses that are less prominent than the main (or primary) stress. For example, the word *manatee* /ˈmænəˌti/ has a primary stress on the first syllable and a secondary stress on the final syllable, as is evident from the non-flapped /t/ in the onset of the final syllable.

2.2 Evidence for stress

2.2.1 Phonetic exponents

Acoustic correlates of stress include increased duration, higher fundamental frequency (pitch), greater overall intensity (loudness), and spectral attributes such as an increased weighting in favor of higher frequencies and a shift in vowel quality (see chapter 9 for discussion). There is considerable cross-linguistic variation in the properties that mark stress. In a 75-language survey, Gordon and Roettger (2017) find duration to be the most reliable correlate of stress, distinguishing at least two degrees of stress in over 90% of these languages. Other exponents of stress included in their survey (intensity, f0, vowel reduction, spectral tilt) are also predictive of stress in the majority of studies. Acoustic evidence for secondary stress is more tenuous. In virtually all studies in Gordon and Roettger's survey, secondary stress was distinguished from

[1] Some researchers refer to 'accent' rather than 'stress'; see van der Hulst 2014 for terminological matters.

primary stress and/or lack of stress through only a subset of properties, if any at all, that were used to distinguish primary stressed from unstressed syllables.

2.2.2 Speaker intuitions and co-speech gestures

Evidence for stress may also come from speaker intuitions, which may be accessed either directly through questioning or covertly through observation of co-speech gestures, such as beat gestures, tapping, or eyebrow movements, which tend to coincide with peaks in fundamental frequency (e.g. Tuite 1993; Cavé et al. 1996; Leonard and Cummins 2010). In the tapping task commonly employed by stress researchers, speakers are asked to simultaneously tap on a hard surface while pronouncing a word. When asked to tap once, speakers typically tap on the primary stress. Additional prompted taps characteristically coincide with secondary stresses. Tapping has been used to elicit judgments about stress not only for languages with lexically contrastive stress, e.g. noun-verb pairs in English (e.g. *ˈimport* vs. *imˈport*), but also for languages with predictable stress, e.g. Tohono O'odham [Uto-Aztecan; United States] (Fitzgerald 1997) and Banawá [Arawan; Brazil] (Ladefoged et al. 1997). The tapping diagnostic has its limitations, however, and is not successful for speakers of all languages.

2.2.3 Segmental and metrical exponents of stress

Stress also conditions various processes, many of which are phonetic or phonological manifestations of the strengthening and weakening effects discussed earlier. Stressed and unstressed vowels are often qualitatively different. Unstressed vowels are commonly centralized relative to their stressed counterparts, although unstressed high vowels are more peripheral in certain languages (see Crosswhite 2004 for the typology of vowel reduction). Unstressed vowels in English typically reduce to a centralized vowel, gradiently or categorically. Gradient reduction occurs in the first vowel in [ɛ]*xplain*/[ə]*xplain*. Such qualitative reduction is typically attributed to articulatory undershoot due to reduced duration, which precludes the attainment of canonical articulatory targets (Lindblom 1963). Categorical reduction in English can often be argued to have a derivational status, as in the case of the second vowel in *ˈhum*[ə]*n* in view of its stressed counterpart in *huˈm*[æ]*nity*, but underived reduced vowels are frequent, like those in the second syllables of *totem* and *manatee* mentioned in section 5.1.

Vowel devoicing is another by-product of undershoot in the context of voiceless consonants or right-edge prosodic boundaries, contexts that are characteristically associated with laryngeal fold abduction which may overlap with a vowel, especially if unstressed. For example, in Tongan [Austronesian; Tonga] (Feldman 1978), an unstressed high vowel devoices when it occurs after a voiceless consonant and either before another voiceless consonant or utterance-finally, e.g. /ˈtuk[i̥]/ 'strike', /ˈtaf[u̥]/ 'light a fire', /ˌpas[i̥]ˈpas[i̥]/ 'applaud' (see Gordon 1998 for the typology of devoicing).

Deletion is an extreme manifestation of reduction. For example, the first vowel in *t*[ə]ˈ*mato* and the middle vowel in ˈ*fam*[ə]*ly* are often absent in rapid speech. In San'ani Arabic [Afro-Asiatic; Yemen], unstressed vowels optionally delete, e.g. /fiˈhimtiː/ ~ /ˈfhimtiː/ 'you F.SG understood', /kaˈtabt ~ ˈktabt/ 'I wrote' (Watson 2007:73). Vowel deletion often parallels devoicing in displaying gradience and optionality. Furthermore, deletion is often only a perceptual effect of shortening as articulatory traces of inaudible vowels may remain (see Gick et al. 2012).

A complementary effect to reduction is strengthening in stressed syllables (see Bye and de Lacy 2008 for an overview). For example, short vowels in stressed non-final open syllables in Chickasaw [Muskogean; United States] are substantially lengthened (Munro and Ulrich 1984, Gordon and Munro 2007), e.g. /ʧiˌpisaˌliˈtok/ → [ʧiˌpiːsaˌliːˈtok] 'I looked at you', /aˌsabiˌkaˈtok/ → [aˌsaːbiˌkaːˈtok] 'I was sick'. Stressed syllables may also be bolstered through consonant gemination, e.g. Delaware [Algonquian; United States] /nəˈməˑtəmeː/ → [nəˈmətˑtəmeː] (Goddard 1979: xiii). Gemination in this case creates a closed and thus heavy syllable (see section 3.3 on syllable weight). 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).

Stress may also have phonological diagnostics extending beyond strengthening and weakening. In the Uto-Aztecan language Tohono O'odham (Fitzgerald 1998), traditional song meter is sensitive to stress. The basic stress pattern (subject to morphological complications not considered here) is for primary stress to fall on the first syllable and secondary stress to occur on subsequent odd-numbered syllables (Fitzgerald 2012; see section 3.5 on rhythmic stress): /ˈwa-paiˌla-dag/ 'someone good at dancing', /ˈʧipoˌs-id-a-ˌkuɖ/ 'branding instrument'. 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; these restrictions trigger syllable and vowel copying processes (Fitzgerald 1998).

Stress may also be diagnosed through static phonotactic restrictions, like the confinement of tonal contrasts to stressed syllables in Trique (DiCanio 2008), the restriction of vowel length contrasts to stressed syllables in Estonian [Uralic; Estonia] (Harms 1997), or the occurrence of schwa in unstressed syllables in cases where there is no evidence for an underlying full vowel.

2.2.4 Distributional characteristics of stress

There are certain properties associated with 'canonical' stress systems (see Hyman 2006 for a summary). One of these is the specification of the syllable as the domain 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, the mora.

Another potentially definitional characteristic of stress is 'obligatoriness', the requirement that every word have *at least* one stressed syllable. Obligatoriness precludes a system in which stress only occurs on certain words but not others. Obligatoriness holds of phonological rather than morphological words; thus, a function word together with a content word, e.g. *the man,* constitutes a single phonological word. Unlike stress systems, canonical tone systems do not require every word to have tone.

The complement of obligatoriness is 'culminativity', which requires that every word have *at most* one syllable with primary stress. Most, if not all, stress systems obey culminativity. Culminativity is not, however, definitional for stress since there are certain tone languages that only allow a single lexically marked tone per word, e.g. Japanese [Japonic; Japan]. These are often called 'restricted tone languages' (Voorhoeve 1973).

Although syllable integrity, obligatoriness, and culminativity are characteristic of most stress systems, each of them has been challenged as a universal feature of stress systems. Certain Numic [Uto-Aztecan; United States] languages, like Southern Paiute (Sapir 1930) and Tümpisa Shoshone (Dayley 1989), are described as imposing a rhythmic stress pattern sensitive to mora count, a system that allows for either the first or the second half of a long vowel to bear stress, a

violation of syllable integrity. Some languages are described as violating obligatoriness in having stressless words, e.g. words lacking heavy syllables in Seneca [Iroquoian; United States] (Chafe 1977), phrase-final and isolation words of the shape CVCV(C) in Central Alaskan Yupik [Eskimo-Aleut; United States] (Miyaoka 1985, Woodbury 1987; see chapter 19 for discussion of Yupik). Other languages are said to have multiple stresses per word none of which stands out as the primary stress, like Central Alaskan Yupik (Woodbury 1987), Tübatulabal [Uto-Aztecan; United States] (Voegelin 1935), a violation of culminativity. Hayes (1995) suggests that isolated violations of syllable integrity, obligatoriness, and culminativity, are amenable to alternative analyses that preserve these three proposed universals of stress.

5.3 Typology of stress

The typology of stress systems has been extensively surveyed (e.g., Hyman 1977; Bailey 1995; Gordon 2002; Heinz 2007; van der Hulst and Goedemans 2009; van der Hulst et al. 2010; Goedemans et al. 2015). We summarize here some of the results of this research program.

5.3.1 Lexical vs. predictable stress

A division exists between languages in which stress is predictable from phonological properties such as syllable location and shape and those in which it varies as a function of morphology or lexical item. Finnish [Uralic; Finland] (Suomi et al. 2008), in which primary stress falls on the first syllable of every word, provides an example of phonologically predictable stress. At the other extreme, Tagalog [Austronesian; Philippines] (Schachter and Otanes 1972) words may differ solely on the basis of stress, e.g. /ˈpito/ 'whistle' vs. /piˈto/ 'seven'. In reality, degree of predictability of stress represents more of a continuum than a binary division, since most languages display elements of both contrastive and predictable stress. For example, although stress in Spanish is lexically distinctive, e.g. /ˈsabana/ 'bed sheet' vs. /saˈbana/ 'savannah', it is confined to a three-syllable window at the right edge of a word with a strong statistical preference for the penultimate syllable (Roca 1999; Peperkamp et al. 2010). Similarly, stress-rejecting affixes in Kabardian [Northwest Caucasian; Russia] (Gordon and Applebaum 2010) create deviations from the otherwise predictable stress pattern, e.g. predictable penultimate stress in /ˈməʃɐ/ 'bear' vs. final stress in /məˈʃɐ/ 'this milk' attributed to the stress-rejecting prefix mə- 'this'.

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5.3.2 Quantity-insensitive stress

Phonologically predictable stress systems differ depending on their sensitivity to the internal structure of syllables. In languages with 'quantity-insensitive' or 'weight-insensitive' stress, stress falls on a syllable that occurs at or near the periphery of a word. For example, Macedonian [Indo-European; Macedonia] stresses the final syllable of words (Lunt 1952, Franks 1987): voˈdeniʧar 'miller', vodeˈniʧari 'miller-PL', vodeniˈʧarite 'miller-DEF.PL'.

Surveys reveal five robustly attested locations of 'fixed stress': the initial, the second, the final, the penultimate, and the antepenultimate syllable. Third syllable is a more marginal pattern, reported for Ho-chunk [Siouan; United States] (but see discussion of alternative tonal analyses in Hayes 1995) and as the default pattern in certain languages with lexical stress, e.g., Azkoitia Basque [isolate; Spain] (Hualde 1998]. Three stress locations (initial, penultimate and final) statistically predominate, as illustrated in Figure 1 based on the StressTyp2 (Goedemans et al. 2015) database of 699 languages.

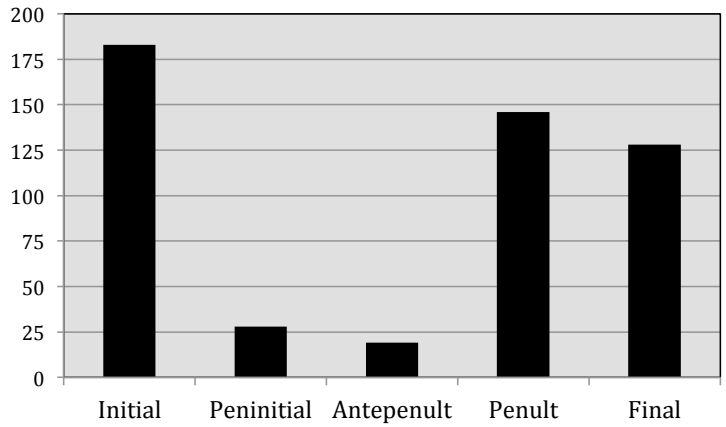

Figure 1. Number of languages with different fixed stress locations according to StressTyp2 (Goedemans et al. 2015).

5.3.3. Quantity-sensitive stress

In many languages, stress is sensitive to the internal structure or 'weight' of syllables, where criteria for which syllables count as 'heavy' vary across languages (Hayes 1989; Gordon 2006).

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For example, in Piuma Paiwan [Austronesian; Taiwan] (Chen 2009), stress typically falls on the penultimate syllable of a word: /kuˈvuvu/ ‘my grandparents’, /səmuˈkava/ ‘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 too contains schwa): /qapəˈdu/ ‘gall’, /ʎisəˈqəs/ ‘nit’.

The rejection of stress by schwa is part of a cross-linguistic weight continuum in which non-low central vowels are lighter in some languages than peripheral vowels. Among peripheral vowels, languages may treat low vowels as heavier than non-low vowels or non-high vowels as heavier than high vowels (Kenstowicz 1997, De Lacy 2004, Gordon 2006; see, however, Shih 2016, 2018, Rasin 2016, for the paucity of compelling evidence for vowel quality-based stress).

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It is more common for a weight-sensitive stress system to be sensitive to the structure of the syllable rime than to vowel quality (see Gordon 2006 for statistics). 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. For example, in Kabardian (Abitov et al. 1957; Colarusso 1992; Gordon and Applebaum 2010), stress falls on a final syllable if it is either CVV or CVC, otherwise on the penult: /sɐˈbən/ ‘soap’, /saːˈbiː/ ‘baby’, /ˈwənɐ/ ‘house’, /χɐrˈzənɐ/ ‘good’. Tone may also condition stress in some languages, where higher tones are preferentially stressed over lower tones (de Lacy 2002).

In some languages, weight is scalar (Hayes 1995, Gordon 2006), and in others, weight is sensitive to onset consonants (Gordon 2005, Topintzi 2010; see section 7). Pirahã (Everett and Everett 1984, Everett 1988) observes a scalar weight hierarchy that simultaneously appeals to both onset and rimal 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 rime-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 rimal weight is mirrored language-internally: onset weight almost always implies rimal weight and where the two co-exist, rimal weight takes priority over onset weight. This dependency is exemplified in Pirahã, where a heavier rime (one consisting of a long vowel) outweighs a heavier onset (one containing a voiceless consonant), i.e. GVV outweighs KV.

5.3.4. Bounded and unbounded stress

In the stress systems discussed thus far, stress is limited, or 'bounded', to a range of syllables at a word edge. For example, in Piuma Paiwan, which avoids stress on schwa (Chen 2009; section 3.3), stress falls on one of the last two syllables, even if there is a peripheral vowel to the left of the penult and the final two syllables both contain schwa. Stress windows are also observed at the left edge in some languages. In Capanahua [Panoan; Peru] (Loos 1969; Elías-Ulloa 2009), stress falls on the second syllable if it is closed, but on the first otherwise, as seen in /ˈmapo/ 'head', /ˈwaraman/ 'squash', /piʃˈkap/ 'small', /wiˈrankin/ 'he pushed it' (see van der Hulst 2010 for more on window effects for weight-sensitive stress). As the word /ˈwaraman/ indicates, stress is limited to the first two syllables even if these are light and a syllable later in the word is heavy.

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Lexical stress may also be bound to stress windows. 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, where the default stress location is the second syllable: /ˈhumisi/ 'run away PL.' vs. /aˈsisi/ 'get up' vs. /biniˈhi/ '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-ˈsa/, 's/he is saying' and /ʧapi-ˈsa/ 'S/he is grabbing', but not in /ruruˈwa-sa/ 's/he is throwing liquid'.

Not all weight-sensitive or lexical stress systems are bounded. For example, stress in Yana [isolate; California] (Sapir and 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 Yana featuring unbounded stress may either have initial stress in the default case, as in Yana, or may have default final stress, as in Kʷakʼʷala [Wakashan; Canada] (Boas 1947; Bach 1975; Wilson 1986; Shaw 2009; Gordon et al. 2012).

If, in languages with unbounded stress, several morphemes with inherent stress are combined into a complex word, the leftmost or rightmost among them will attract stress. This situation parallels unbounded weight-sensitive stress, if lexical stress is viewed as diacritic weight (van der Hulst 2010). In both cases, stress defaults to the first or last syllable (or the peninitial or penult, if extrametricality/non-finality applies) if no heavy syllable is present. 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 if there is no syllable with diacritic weight: /gospoˈʒa/ ‘lady’, /koˈrova/ ‘cow’ vs. /ˈzʲerkalo/ ‘mirror’, /ˈporox/ ‘powder’ (Halle 1973).

5.3.5 Secondary stress

In certain languages, longer words may have one or more secondary stresses. In some, 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 /ˌsiˈnoqo/ ‘cork’, /ˌkenaˈɯuli/ ‘fishing hook’. In other languages, secondary stress rhythmically propagates from either the primary stress or from a secondary stress at the opposite edge from the primary stress. Rhythmic stress was exemplified earlier (see section 2.3) for Tohono O’odham, in which primary stress falls on the first syllable and secondary stress falls on subsequent odd-numbered syllables: /ˈwa-paiˌla-dag/ ‘someone good at dancing’, /ˈʧipoˌs-id-a-ˌkuɖ/ ‘branding instrument’.

Languages with a fixed primary and a single fixed secondary stress are relatively rare compared to those with 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 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.

Even rarer are hybrid ‘bidirectional’ systems in which one secondary stress ‘wave’ radiates from the primary stress with a single secondary stress occurring on the opposite edge of the word. For example, primary stress in South Conchucos Quechua [Quechuan; Peru] (Hintz 2006) falls on the penult, with secondary stress docking on both the initial syllable and on alternating syllables to the left of the penult, as in /ˌwaˌraːkaˌmunqaˈnaʧi̯/ ‘I crunch up my own (e.g. prey) with teeth’. The bidirectional nature of stress leads to adjacent stresses (i.e., stress clashes) in words with an odd number of syllables. In some bidirectional systems, like Garawa [Australian; Australia] (Furby 1974), rhythmic stress is suppressed where it would result in a stress clash.

Another rare system has stress on every third syllable. For example, primary stress in Cayuvava [isolate; Bolivia] (Key 1961, 1967) falls on the antepenultimate syllable and secondary stress falls on every third syllable to the left of the primary stress: /ikiˌtapareˈrepeha/ ‘the water is clean’, /ˌʧa.adiˌroboβuˈuruʧe/ ‘ninety-five (first digit)’. Stresstyp2 (Goedemans et

al. 2015) cites only two quantity-intensitive stress systems with stress on every third syllable, although there are a few quantity-sensitive stress languages (see section 5.2) in which ternary intervals occur in sequences of light syllables (see Hayes 1995).

Stanton's (2016) survey of word length in 102 languages suggests that rhythmic stress (generalized over all sub-types) is especially prevalent in languages with longer words, whereas single stress systems are more common in languages with fewer long words. Figure 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). Non-stress 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.

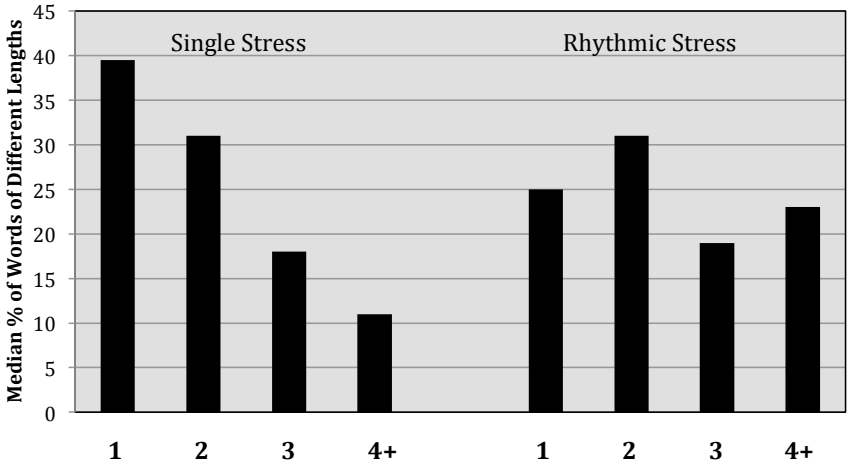

Figure 2. Median percentage of words with differing numbers of syllables in languages with a single stress per word and those with rhythmic secondary stress in Stanton (2016).

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 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. A more cynical view might attribute the link between word length and rhythmic stress to the perceptual transfer of rhythmic secondary stresses by researchers accustomed to hearing secondary stresses in their native language, a phenomenon that Tabain et al. (2014) term 'stress ghosting'.

A recurring feature of languages with rhythmic secondary stress is that the primary stress serves as the starting point for the placement of secondary stresses (van der Hulst 1984). Thus, in a language with rightward propagation of secondary stress, e.g., Tohono O'odham, the primary stress is the leftmost stress, whereas in languages with leftward iteration of secondary stress, e.g. Émérillon [Tupian; French Guiana] (Gordon and Rose 2006) and Cayuvava [isolate; Bolivia] (Key 1961, 1967), the rightmost stress is the primary one.

Systems in which the stress at the endpoint of the rhythmic train is the primary one are comparatively rare. Virtually all of the exceptions to this generalization involve cases of rightward propagation of stress and the rightmost stress being the primary one, a pattern that plausibly reflects phrasal pitch accent rather than word stress (van der Hulst 1997; Gordon 2014). Perhaps the only case in the literature of leftward stress assignment and promotion of the leftmost stress to the primary one is found in Malakmalak [Australian; Australia] (Birk 1976).

5.3.6 Non-finality effects

Many stress systems exhibit a bias against (primary or secondary) stress on final syllables. Final stress avoidance has different manifestations. 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. /ˈsaːlpmaˌkirːje/ 'psalm book NOM.SG', /ˈkuhkaˌjolkikijt/ 'long-leg-NMLZ-ACC.PL'. Other languages may stress the second syllable of a word, but not if that stress would be final. For example, in Hopi (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: /kiˈjapi/ 'dipper', /laˈqana/ 'squirrel', /ˈkoho/ 'wood', /ˈmaqa/ 'to give'.

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Another species of non-finality occurs in weight-sensitive systems in which final weight criteria are more stringent than in non-final syllables, a pattern termed 'extrametricality' (Hayes 1979). Thus, in Cairene Arabic [Afro-Asiatic; Egypt] (Mitchell 1960, McCarthy1979, Watson 2007), CVC attracts stress in the penult, as in /muˈdarris/ 'teacher M.SG.', but a final syllable containing a short vowel must have two coda consonants (CVCC) to attract stress, cf. /xaˈbiːr/ 'specialist', but /ˈasxan/ 'hotter' (see Rosenthall and van der Hulst 1999 for more on context-driven weight for stress).

5.4 Rhythmic stress and the foot

Languages with rhythmic stress have provided the impetus for theories that assume the foot as a prosodic constituent below the word (e.g. Liberman and Prince 1977; Selkirk 1980, Hayes 1980, 1995; Halle and Vergnaud 1987; Halle and Idsardi 1995). In these theories, foot type is treated as a parameter with certain languages employing trochaic feet, which consist of strong-weak pairs of syllables, and others opting for iambic feet, consisting of weak-strong pairs. Tohono O'odham provides an example of trochaic footing where in words with odd syllables the final syllable constitutes a monosyllabic foot, as in /(ˈʧiːpo)(ˌsida)(ˌkuɖ)/ 'branding instrument' (cf. /(ˈwapai)(ˌladag)/ 'someone good at dancing'). The mirror-image trochaic system stresses even-numbered syllables counting from the right, as in Émérillon (excluding words with a final heavy syllable, which attract stress from the penult) (Gordon and Rose 2006): /(ˌmana)(ˈnito)/ 'how', /(ˌdeze)(ˌkasi)(ˈwaha)/ 'your tattoo'.

Osage [Siouan; United States] (Altshuler 2009), in which stress falls on even-numbered syllables counting from the left, exemplifies iambic stress: /(xoːˈtso)(ðiːbˌrã)/ 'smoke cedar', /(ãːˈwã) (lɑːˌxy)ɣe/ 'I crunch up my own (e.g. prey) with teeth'. (The final syllable remains unfooted to avoid a stress clash with the preceding syllable.) Its mirror image iambic pattern stresses odd-numbered syllables from the right, as in Urubú Kaapor (Kakumasu 1986).

Trochaic stress patterns predominate cross-linguistically. In Stresstyp2, the Tohono O'odham-type trochaic pattern is found in 42 languages, while the Émérillon-type trochaic system is found in 40 languages. In contrast, their inverses, Osage iambic and Urubú Kaapor iambic systems are observed in only 7 and 13 languages, respectively

The alternative to a foot-based theory of stress represents stress only in terms of a prominence grid (e.g. Liberman and Prince 1977; Prince 1983; Selkirk 1984; Gordon 2002), in

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which stressed syllables project grid marks while unstressed ones do not. Differences in level of stress, e.g. primary vs. secondary stress, are captured in terms of differences in the number of grid marks dominating a syllable. Foot-based theories assume that the grid marks are grouped into (canonically) disyllabic constituents, although single syllables may be parsed into feet at the periphery of a word, as in Tohono O'odham. Foot-based and grid-based representations of stress are exemplified for Tohono O'odham in (1).

(1)	*Foot-based*	*Grid-based*
Level 1 (Primary stress)	(x)	x
Level 2 (Secondary stress)	(x .)(x .) (x)	x x x
	(ˈʧɨpo)(ˌsida) (ˌkuḍ)	ˈʧɨpo ˌsida ˌkuḍ

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Phonologists have long debated the role of the foot in the analysis of stress (see Hermans 2011). An asymmetry between trochaic and iambic feet in their sensitivity to weight provides one of the strongest pieces of evidence for the foot. Unlike quantity-insensitive rhythmic stress systems, which are biased toward trochees, quantity-sensitive rhythmic stress tends toward iambic groupings with an ideal profile consisting of a light-heavy sequence, an asymmetry termed the 'Iambic-Trochaic Law'. Chickasaw instantiates a prototypical iambic language in which stressed light (CV) syllables are lengthened non-finally (see section 2.3) and all heavy (CVV, CVC) syllables are stressed: /(ʧi ˌkaʃ)(ˈʃaʔ)/ 'Chickasaw', /(ˈna:ɬ)(to ˌkaʔ)/ 'policeman', /ʧi ˌpisa ˌliˈtok/ → /(ʧi ˌpi:)(sa ˌl[i:])(ˈtok)/ 'I looked at you'. In contrast to iambic feet, trochaic feet in some languages are subject to shortening of stressed vowels to produce a canonical light-light trochee, e.g. Fijian /mɓu:ŋg͡u/ → /(ˈmɓ[u].ŋg͡u)/ my grandmother' (Schütz 1985).

5.5 Outstanding issues in word stress

5.5.1 The diagnosis of stress

Stress is easily identified in its prototypical instantiation in which phonetic and phonological exponents, speaker intuitions, and distributional characteristics converge. There are many languages, however, in which evidence for stress is more ambiguous. It is thus often difficult to determine whether prominence should be attributed to stress rather than other properties, including tone, intonation, and the marking of prosodic boundaries (see Gordon 2014, Roettger

and Gordon 2017 for discussion). Raised pitch could thus potentially reflect a high tone in a tone language, a phrase- or utterance-initial boundary tone, or be triggered by focus. Similarly, increased length could be attributed to a prosodic boundary rather than stress.

Distributional restrictions on other phonological properties may be diagnostic of stress in lieu of obvious phonetic exponents or phonological alternations. For example, certain Bantu languages preferentially restrict high tone to a single syllable per word (Hyman 1989; Downing 2010), a distribution that is consistent with the property of culminativity holding of canonical stress systems (section 2.4).

There are also languages in which potential phonetic correlates of stress may 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] (Dubina 2012; Borise 2015) and Welsh [Indo-European; United Kingdom] (Williams 1983, 1999) with cues to stress spread over the stressed and adjacent syllable. Non-convergence may be due to the existence of multiple prominence systems, e.g. intonation vs. word-level stress, or to a diffuse phonetic realization of stress, e.g. a delayed or premature f0 peak relative to the stress.

5.5.2 Stress and prosodic taxonomy

Stress is widespread in languages of the world. Of the 176 languages included in the 200-language WALS sample, approximately 80% (141 languages) are reported to have stress (Goedemans 2010: 649; see chapter 9 for a lower estimate). Phonemic tone and stress have traditionally 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, e.g. Thai [Tai-Kadai; Thailand] (Potisuk et al. 1996), Papiamentu [Portuguese Creole; Aruba] (Remijsen and van Heuven 2002), and Pirahã (Mura-Pirahã; Brazil] (Everett and Everett 1984, Everett 1988) or in a dependent relationship, in which tone is predictive of stress, e.g. Ayutla Mixtec [Otomanguean; Mexico] (Pankratz and Pike 1967, de Lacy 2002), or stress is predictive of tone, e.g. Trique [Otomanguean; Mexico] (DiCanio 2008, 2010).

On the other hand, there are several languages that have traditionally been regarded as stress languages, but that are now generally considered languages in which prominence can be linked to phrasal pitch events rather than word-level stress (or tone), e.g. French [Indo-European;

France] (Jun and Fougeron 1995), Korean [Koreanic; Korea] (Jun 1993), Indonesian [Austronesian; Indonesia] (van Zanten et al. 2003), Ambonese Malay [Austronesian; Indonesia] (Maskikit-Essed and Gussenhoven 2016), West Greenlandic [Eskimo-Aleut; Greenland] (Arnhold 2014) and Tashlhiyt [Afro-Asiatic; Morocco] (Roettger et al. 2015). These languages all share in common pitch events that occur near the edges of prosodic domains larger than the word, though they differ in the consistency of the timing of the pitch events.

5.5.3 Stress typology and explanation

A burgeoning area of research explores various perceptual and cognitive motivations behind stress patterns. For example, several scholars have developed phonetically-driven accounts of onset weight that appeal to auditory factors such as perceptual duration (Goedemans 1998), adaptation and recovery (Gordon 2005), and perceptual p-centers (Ryan 2014). Gordon (2002) offers an account of rime-sensitive weight appealing to the non-linear mapping between acoustic intensity and perceptual loudness and to the temporal summation of energy in the perceptual domain. Non-finality effects have been linked to an avoidance of tonal crowding between the high pitch characteristic of stress and the default terminal pitch fall typically associated with the right edge of an utterance (Hyman 1977; Gordon 2001, 2014). Lunden (2010, 2013) offers an account of final extrametricality based on differences in the relative phonetic duration of syllables in final vs. non-final syllables. Stanton (2016) hypothesizes that the absence of languages that orient stress towards 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.

5.6 Conclusion

Although a combination of typological surveys of stress and detailed case studies of particular languages has revealed a number of robust typological generalizations governing stress, many questions still remain. These include the abstract vs. physical reality of stress, the relationship between word stress and prominence associated with higher level prosodic units, and the role of functional and grammatical factors in explaining the behavior of stress. The continued expansion

of typological knowledge gleaned from phonological, phonetic, and psycholinguistic studies of stress will continue to shed light on these issues (but will undoubtedly raise more questions).

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