Part I

Domains of Linguistic Typology

2

Phonological Typology

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2.1 Introduction

Phonology has been characterized as 'special' in both typological and theoretical studies. Hyman (2007a) observes that some major typological textbooks largely ignore phonology,[1] while Bresnan (2007) notes that '[t]ypology has a low profile in much of American linguistics, especially outside of phonology', apparently having in mind that theoretical work in phonology seems inherently more typological in its approach than theoretical work in other areas of the grammar, such as morphosyntax. Hyman also remarks that phonology, as a field, has characteristically been more unified (than syntax) despite theoretical differences, and also inherently more interested in studying a broad variety of languages in order to gain theoretical insight into the nature of phonological systems. Indeed, many of the earlier twentieth-century works in phonology typically contain claims about aspects of phonological systems that are based on and illustrated with multiple languages. This is clear in discussions of phonemic inventories in, for example, Trubetzkoy (1939), Martinet (1964) and Hockett (1955). The general typological nature of phonological research may, as Hyman suggests, be due to the fact that phonology is in some sense 'simpler' than syntax which might allow phonologists to consider cross-linguistic data and analyses more readily.

Within the 'American school' of typological linguistics, the so-called Greenberg school, many typological studies of phonological phenomena were produced during the 1970s on, for example, vowel inventories, metathesis, tone, vowel harmony, stress, consonant clusters, syllabic consonants, nasal vowels, intonation, phonological processes and so on (many of which are collected in Greenberg, Ferguson and Moracszik 1978).[2] More recent years have witnessed many more typological studies, often in the form of, or based on, digital databases which have come to replace the pencil-and-index card and notebook collections of earlier years. While

several of those more recent database projects reflect the old-style goal of collecting information about many languages and formulating statistical tendencies, a significant trend in phonology is also a sizeable number of theory-driven studies that contain or are based on broad surveys of specific phenomena (e.g. Hayes 1981; Leitch 1996; Kaun 1995, etc.). Such studies (often dissertations) have clearly risen above the level of supporting theories with 'illustrative examples'. These kinds of studies, in conjunction with earlier typological studies, have been of great significance for the development of highly articulated phonological theories of specific phenomena such as stress and vowel harmony, allowing fine-grained formal accounts of subtle differences between systems that in earlier work had been treated more holistically. For example, where earlier work on word stress would refer to gross distinctions such as 'initial, final and penultimate stress' (see Hyman 1977), the advent of 'parameters' in generative linguistics has given rise to much more detailed classifications (see Hayes 1995 on stress and Archangeli and Pulleyblank 1994 on vowel harmony). Such works exemplify and amplify Hyman's claim that phonological theory is typically based on a broad range of cross-linguistic data (including both the 'older' studies and new collections), and thus, in a sense, narrowing (or simply denying) the gap between traditional typological and so-called theoretical work.[3]

In this chapter I provide an overview of typological studies in the area of phonology, focusing both on approaches and on results.[4] I will also suggest potential new lines of typological research. The following sections will deal with the various properties that make up phonological systems: features/elements and segmental inventories (§2.3), syllable structure (§2.4), stress (§2.5), tone (§2.6), prosodic domains (§2.7), intonation (§2.8) and rules/processes (§2.9). Section 2.10 discusses so-called holistic typologies (dealing with correlations between phonology and other components of the grammar) as well as phonology-internal typological correlations. Section 2.11 offers some conclusions and prospects for further research.

2.2 Methodological Issues

I refer to Chapter 1 of this handbook for a general discussion of methodological issues that arise in typological studies. Here I will mention only a classical example of the tension between broad surveys that cover many languages and in-depth analysis of individual systems with respect to what is perhaps the most typical example of phonological typology, namely the study of vowel and consonant inventories. When IPA symbols are used to represent such inventories, uncertainty can easily arise as to whether these symbols refer to phonetic entities or phonemic entities. The goal of existing databases for inventories has been to represent *phonemic*

distinctions and thus abstract away from allophones, but the distinction is not always easy to make.[5]

A related problem that arises in the study of segment inventories (perhaps more so for vowels than for consonants) is that even among small inventories, descriptions might use IPA transcriptions that suggest small differences. It is common in the typological literature to *normalize* systems of vowels that are phonetically different (such as 1a and 1b) to the same phonemic system (1c):

(1) a. [i] [u]
[ɒ]
b. [ɪ] [ʊ]
[a]
c. /i/ /u/
/a/

Thus, among all the languages with three-vowel systems of the 'iua' type, the exact vowel qualities of these three vowels are not always the same. The /i/ phoneme does not always have to sound like [i]; it can also have an [ɪ] quality. Likewise, the low vowel /a/ can vary (e.g. be [a] or [ɐ]).

The question arises as to what the limits are of normalization. For example, what do we do with the following, less common, four-vowel systems (Lass 1984):

(2) a. i
e o
a
(Campa)

b. i u
ɛ ɔ
a
(Cayapa)

c. i ɨ
a
(Chacobo)

d. /i/ /u/
/ə/
/a/

Are we allowed to normalize these systems to the phonemic representation in (2d) (with a rather arbitrary choice for the 'fourth' vowel)? Can we reasonably say that the [o] or [ɔ] in these systems are realizations of the phoneme category /u/?

A deeper problem, perhaps, is that placing IPA symbols between slant lines does not in itself designate a unique phonemic analysis. IPA symbols are mere shorthand for feature representations (at least, according to most theories of phonology). Here the issue is that a system which is suggested to have, say, three vowels (i.e. /i/, /u/ and /a/) can have more than one feature representation for the vowels in it. This problem was pointed out in Sapir (1925) who argued that a representation of a system in terms of IPA symbols can be ambiguous with respect to the phonemic behaviour* of the units in it and, conversely, that two different IPA notations might reflect one and the same system when the phonological behaviour of

segments is considered. In other words, there is a many-to-many relationship between IPA symbols and phonemes. The different phonemic status of segments that are identically represented in terms of IPA is brought into clear focus when feature representations of phonemes are kept minimal. Dresher (2009) revives the idea that phonemic specifications can result from different language-specific feature hierarchies that reflect which features are active in the phonology of a given language. If such an approach is correct, typologies should be based on minimal feature representations of phonemes and not on IPA symbols, even when these are meant to reflect phonemic distinctions.

2.3 Features/Elements and Segmental Inventories

2.3.1 Economy and Feature Hierarchies

The logical place to start typological research is by looking at the basic building blocks. Most typological and theoretical work adopts the working hypothesis that phonological segments as 'vertical slices of the speech signal' (despite their alphabetic orthographic bias) are useful theoretical constructs (even if not clearly detectable at the phonetic level, mainly to account for the more discrete organization at the phonemic level where such units are called *phonemes*). Additionally, it is usually assumed that such segments 'consist of' or can be characterized as sets of smaller units, called *features* (specifically, *distinctive features* at the phonemic level). The development of feature theory (following Jakobson, Fant and Halle 1952) up to the present usually comes with the idea that all features are universal, which means 'available to all languages', perhaps as a result of being innate.[6] The view that languages do not necessarily employ all features opens the door to typological research regarding the cross-linguistic activity of features and, moreover, feature values.[7]

Starting with feature values, it has often been noted that there is an asymmetrical distribution of the plus and minus value of a given feature. Such asymmetries qualify as unidirectional implications which developed into the theory of markedness (Steriade 1995). There are context-free and context-sensitive markedness statements (ATR = Advanced Tongue Root):

(3) a. For the feature [nasal] '+' is marked (for both consonants and vowels)
    b. For the feature [continuant] '+' is the marked value

(4) a. For the feature [ATR] '−' is the marked value for vowels that are [+high]
    b. For the feature [voice] '−' is the marked value for segments that are [+sonorant]

The typological study of features and feature values is necessarily connected to, and hard to separate from, the study of inventories, since it is foremost through inventories that we establish which features are necessary in individual languages.[8] From the earliest work on inventories, it has been found that the organization of inventories is not random. Inventories display a certain structure, specifically a *symmetry*. For example, place of articulation distinctions tend to be similar across manner of articulation. Noting this fact, Martinet (1964) proposed a *principle of economy* to account for such findings, a line of work that has been revived and extended in Clements (2009). The general idea is that feature distinctions are put to maximal use, which then entails that smaller inventories will use fewer features than larger inventories.[9]

Economy in itself does not entail *which* features are 'activated' contrastively in a certain language, if not all are needed, as we would expect in smaller inventories. Conceivably, it could have been that languages with equal inventory sizes would activate features randomly from the total available set, resulting in wildly different inventories of the same size. This is not what we see. It would appear that, by and large, features are activated in a certain order. We can illustrate this by looking at vowel inventories.

2.3.2 Vowel Inventories

Vowel inventories range from two to two dozen, with an average around five or six.[10] A well-known observation is that in very small, so-called vertical vowel systems, aperture distinctions (however encoded in features) come before colour distinctions (front/back and rounding). There are two- or three-vowel systems that distinguish vowels in terms of *aperture* alone, but there are no systems of this size that only use colour distinctions (palatality, labiality). Kabardian (a north-west Caucasian language) has been claimed to have such a minimal vertical system:[11]

(5) ɨ
a (and a long counterpart /a:/)

To explain such effects, phonologists have proposed *feature hierarchies* (see van den Broecke 1976).

While these approaches resort to more or less formal properties of feature theories (such as economy and hierarchies of features) to explain the structure of inventories, a different line of work aims at predicting the structure of inventories on the basis of purely phonetic factors, starting with the work of Liljencrants and Lindblom (1972), who propose their *Adaptive Dispersion Theory*. The basic idea is that vowels are placed within the vowel space so as to maximize their perceptual differences. In other words, the main burden is placed on perceptual forces, although articulatory forces can also play a role (see below). It has proven difficult to

precisely formalize this prediction. Liljencrants and Lindblom's formal-computational model nicely predicts the shape of smaller vowel systems (three, four and five vowels), but discrepancies already arise with five-vowel systems. Other authors (e.g. Schwartz et al. 1997) have proposed modified theories. For a critical assessment of such predictive systems, see Vaux and Samuels (2015), who propose to attribute an important role to principles of historical change which may lead to synchronic systems that deviate from the 'perceptually ideal' systems; see also Blevins (2004) for a similar approach.

A different approach is offered by the *Quantal Theory* proposed by Stevens (1989). Stevens argues that there are certain regions in the articulatory space within which small changes produce auditory differences that are hardly noticeable. He calls such regions 'quantal' and they correspond to the vowels 'i', 'u' and 'a' in the vowel space.

In non-vertical systems, we observe that among high vowels we find more colour distinctions than among low vowels, giving rise to the typical triangular shape of such systems. A reason for a colour distinction being more likely to occur among the high than the low vowels is simply that the relevant articulatory gestures ([±back] and [±round] are easier to make in the high region. For low vowels, the tongue lies low in the mouth, making it less mobile in the front-back dimension. At the same time, the mouth is more open, which makes it less easy to make a round-spread distinction with the lips. This shows that articulatory ease plays a role in shaping vowel systems (and, as we will see, consonant systems). Without this reasoning, it would be difficult to explain why the following system is never found:

(6) ɨ
æ a

The articulatory facts correlate with the acoustic facts. In acoustic terms, the vowels in this impossible system are less different from each other than the three vowels in the commonly found three-vowel system in which lip rounding and backness work synergistically to accentuate the difference between the two non-low vowels. Thus, from an acoustic point of view, the impossible system is also less preferred.

2.3.3 Consonantal Inventories

In general, much more work has been done on the structure of vowel systems than on the structure of consonant systems, in terms of both data collections and explanation. However, UPSID contains information about both vowels and consonants, and there certainly have also been attempts to explain the structure of consonantal systems. Lindblom and Maddieson (1988) take into account maximal perceptual contrast but, in this case, also reckon with articulatory complexity. These authors propose

that (beyond the ranking of the features themselves, which they do not explicitly discuss) it is necessary to distinguish different *dimensions* of features and a hierarchy among those dimensions, with some being primary and others not.[12] They argue that inventories reveal a preference for simpler over more complex segmental structures. When non-primary dimensions are used, the resulting segment type is more complex. For example, while consonants can have secondary articulations (such as labialization or palatalization), such properties are not frequent and most inventories do without them.[13] If a palatalized consonant is present, presence of the non-palatalized version is implied. We note that once more an important role is carved out for relative complexity. The main idea is that consonantal systems will first 'use' consonant types that are the least complex from an articulatory standpoint: /p, t, k, ʔ, b, d, g, f, s, h, tʃ, m, n, l, r, w, j/. All these consonants are among the twenty most frequent consonants in the languages of the world (Maddieson 1984). Second and third tier consonants will then invoke additional places of articulation, various special phonation properties and complex articulations. While Lindblom and Maddieson (1988) put emphasis on distinguishing different articulatory dimensions, we must assume that, since not all languages make use of all consonants in the most frequently occurring set, some notion of perceptional distance or feature ranking plays a role in determining the nature of smaller inventories.

With reference to feature hierarchies (within dimensions), Clements (2009), based on UPSID, reports results on the use of features in consonantal systems. As in the case of vowels, different languages can vary quite a bit in terms of the number of consonants that they have, ranging from 6 (Rotokas, a language spoken in Papua New Guinea) to 122 (!Xóõ, a Southern Khoisan language). Here are some of the examples that he considers:

(7)

Rotokas				Hawaiian				French			
p	t		k	p	k	ʔ		p	t		k
	b (β)	d	g		m	n	h		b		d
g											
					w	l			f	s	ʃ
									v	z	ʒ
									m	n	ɲ
										l	ʁ
											j

Nepali				
p	t	ts	ʈ	k
p^h	t^h	ts^h	$ʈ^h$	k^h
b	d	dz	ɖ	g
b^h	d^h	dz^h	$ɖ^h$	g^h
			s	ɦ
m	n			(ŋ)
	l, r			

According to Clements's feature theory, the following consonantal features are active ('act') in these systems:

(8)

	Rotokas	Hawaiian	French	Nepali
[sonorant]		Act	Act	Act
[labial]	Act	Act	Act	Act
[coronal]	Act		Act	Act
[dorsal]	Act	Act	Act	Act
[anterior]			Act	Act
[distributed]				Act
[continuant]			Act	Act
[nasal]		Act	Act	Act
[lateral]				Act
[voice]	Act		Act	Act
[spread gl.]		Act		Act
[constricted gl.]		Act		

Given these different patterns of activation, we must assume, as in Dresher's theory (which is mostly applied to vowel systems), that different languages have a different hierarchical ranking of features within each class.

Typological studies of vowel and consonant inventories can be found in the earliest major work on phonology (such as Trubetzkoy 1939 and Hockett 1955). A new wave of studies emerged from Greenberg's project on language universals, followed by the UPSID database developed by Ian Maddieson and Peter Ladefoged (Sedlak 1969; Crothers 1978; Lass 1984; Lindblom 1986; Schwartz et al. 1997; [14] Maddieson 2005a, 2005b, 2005c, 2005d, 2005e, 2007). Here I also mention two other important sources for the typological study of segmental inventories and phonemic contrast. Based on first-hand phonetic studies, Ladefoged and Maddieson (1996) offer a detailed account of all known instances of phonemic contrast in 'the languages of the world'. Also, more recently, a second digital database PHOIBLE containing information of segmental inventories has been made available. The 2014 edition includes 2,155 inventories that contain 2,160 segment types found in 1,672 distinct languages.[15]

2.4 Syllable Structure

In this section I will briefly review some aspects of syllable typology (based on Blevins 1995 and Maddieson 2005f), assuming that all languages group consonants and vowels into syllables. The typology offered here is based on known types of complexities in syllabic structure. It assumes a distinction between core syllables that can occur in all positions in the word and peripheral syllables that occur at word

edges, and aims at the former. Classifying languages as belonging to a certain type thus presupposes careful analysis of each language and a distinction between core and peripheral syllables. There is currently no systematic survey of the syllabic organization in a wide variety of languages, and I therefore refrain from associating languages with the various types mentioned here. Both Blevins (1995) and currently accessible databases that include phonotactic information merely list 'surface patterns' that do not distinguish between core and peripheral syllables.

It would seem to hold that all languages at least have CV syllables. Above that there are significant differences between the complexities of syllables that are allowed in any given language. English allows syllables that range from combinations of simple onsets (or no onset) and branching VX rhymes to CCC onsets and VXC rhymes (mostly in initial and final syllables, respectively), plus some extra coronals at the word end (see Fudge 1987).

Syllables of the type CV seem to form the least complex syllable type, and there are languages that allow only this type (Type 1a). A small variation is shown by languages that also allow V, i.e. onsetless syllables (Type 1b).

(9) Type 1a: CV
Type 1b: CV, V i.e. (C)V)[16]

A further small variation is to allow VV rhymes (i.e. long vowels), with either onsets being obligatory or optional. More complex types usually imply the simpler ones. Hence, a Type 3 language would be expected to be both CV and CVV.

(10) Type 2a: CVV, CV i.e. CV(V)
Type 2b: CVV, CV, VV, V i.e. (C)V(V)

A different degree of further complexity involves the presence of coda consonants. As far as we know, allowing VC rhymes is independent of allowing VV rhymes, but obviously there are languages that allow both:

(11) Type 3a: CVC, CV i.e. CV(C)
Type 3b: CVC, CV, VC, V i.e. (C)V(C)

If a language allows both VV and VC rhymes, we can represent that as follows (where 'X' represents 'C or V'):

(12) Type 4a: CVX, CV i.e. CV(X)
Type 4b: CVX, CV, VX, V i.e. (C)V(X)

Another degree of complexity is to allow branching onsets (CC). It may be true that all languages that allow CC onsets also allow the no-onset option. And some phonologists have argued that branching onsets occur only in

languages that also allow branching rhymes (Kaye and Lowenstamm 1984):

(13) Type 5a: CCVV, CVV, CV, VV, V i.e. (C(C))V(V)
Type 5b: CCVC, CV, VC, V i.e. (C(C))V(C)

With both VV and VC:

(14) Type 6: CCVX, CVX, CV, VX, V i.e. (C(C))V(X)

Certain generalizations are robust:

(15)
- All languages have CV syllables.
- If a language allows clusters of length *n*, it also allows all clusters that are shorter than *n*.
- If a language allows VV rhymes it also allows V rhymes.
- Assuming that it is possible to maintain a distinction between core syllables (i.e. syllables that can occur in all positions in the word) and edge syllables, it might be true that there is a strong tendency for the maximal complexity of core syllables to be:

$$[[CC]_{onset}\ [VX]_{rhyme}]_{syllable}$$

Another dimension of syllable typology looks at the specific segment types of clusters that can occur in syllabic positions. This can regard onset clusters, coda clusters or interlude clusters; see Murray and Vennemann (1983). With reference to this aspect of syllable structure, many phonologists make appeal to the so-called sonority scale:

(16) Sonority scale

low sonority high sonority

vcl stop voiced stops/vlc fricatives voiced fric nasal liquid glide high vow low vow

|———————|———————|—————|——|———|———|—————|

The ranking of segment types on this scale is referenced by statements about syllable structure. There is a strong tendency for syllables to have a sonority profile that rises from the first consonant to the vowel and falls towards the end (see Clements 1990). For example, with the second position in onsets (C2) preferring more sonorous consonants, any language that allowed nasals would be predicted to also allow all other consonants that are more sonorous than nasals:

(17) If C2 allows nasal, then it also allows liquids and glides.

This implicational universal does not say anything about phoneme inventories. Rather, it says something about the phonotactic structure of a language. Zec (1988, 2007), among others, demonstrates that the same sonority scale is also relevant for the syllable coda position, where a tolerance for consonant of sonority value *n* implies tolerance for

consonants with higher sonority.[17] In characterizing clusters, adherence or non-adherence to unmarked sonority profiles are usually of central concern (rising, falling, falling-rising, respectively for onsets, codas and interludes). However, the placement of segment types in either singleton onset or coda position is also at issue. Restrictions on which consonants can occur in the coda are quite common (Zec 1988), but restriction on singleton onsets have also been reported (Flack 2009).

Returning to the difference between core and peripheral syllables, there are languages such as Georgian that have very long consonant clusters, limited to the beginning of the word (Butskhrikidze 2002). Typically, in such cases, violation of sonority sequencing occur. We also find violations of the sonority preferences in languages that have simpler onsets. For example, many Slavic languages (such as Russian) allow words to begin with clusters such as /lb/ or /rt/ or even /vzgl/. Crucially, such languages by implication also allow clusters that are more felicitous from a sonority perspective.

Finally, we also need to mention here the typology of syllable weight, i.e. the classification of syllables in terms of their being heavy or light with respect to accent/stress placement. This typology comes with clear implicational relationships that make reference to sonority. Specifically, it has been claimed that if CVC projects a heavy syllable then CVV should also be heavy, because V is more sonorous than C. More specific examples of implicational relations are discussed in Zec (1988, 2007), Gordon and Applebaum (2006).

Sources for cross-linguistic generalizations about syllable structure, or phonotactic structure in general, are the World Phonotactics Database and the Lyon-Albuquerque Phonological Systems Database (the newest version of UPSID). There is also SylTyp (designed by Harry van der Hulst and Rob Goedemans, which is part of the Typological Database System). Van der Hulst and Ritter (1999) is a collection containing detailed syllabic studies of seventeen languages.

2.5 Stress

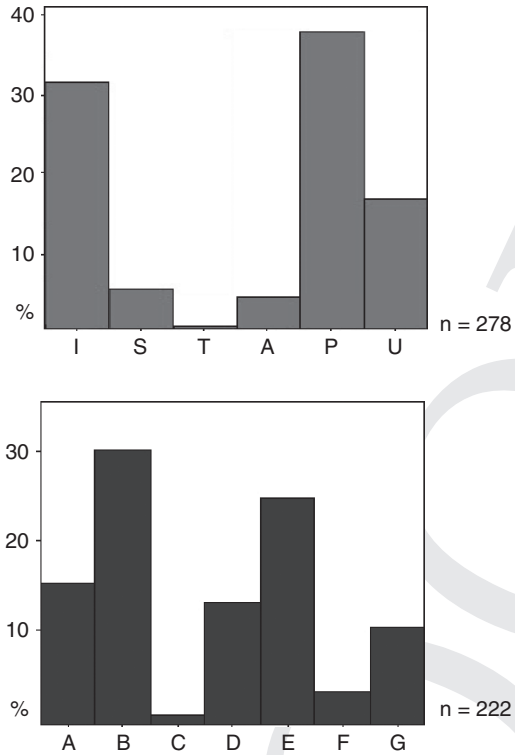
After phoneme inventories, word prosodic systems typology is probably the next most discussed subject in phonological typology; see van der Hulst (2014) for a review, references and proposals.[18]. A foundational topic concerns the three-way classical distinction between stress (or stress accent), pitch accent (or musical accent) and tone systems. Hyman (2007b) disputes the independent status of pitch accent as a separate type of system. In his view there is only 'stress' and 'tone', which may occur separately or jointly in a given language. Pitch-accent systems, in Hyman's view, are simply very reduced tonal systems, up to the point that words can have maximally one tone per word, typically an H tone.

The once-per-word property is what gives such systems the flavor of having 'stress'. Van der Hulst (2011, 2014) promotes the idea that there is only 'accent' and 'tone', with 'stress' (a combination of various phonetic cues such as pitch, duration and amplitude) or 'pitch' (which leads to a pitch-accent system) being phonetic realizations or correlates of accent. While stress accent and pitch accent may be prototypical accent systems, van der Hulst suggests that if, for example, duration is the important or only cue, we can speak of a duration-accent language. There are also tonal languages that restrict tone contrasts to one designated syllable, and such systems would then be tone-accent languages. The proposal here is that there are many types of accent systems, depending on which phonetic or phonemic properties correlate with the accented position.

A potential problem for this view is that in some accent systems, notoriously pitch-accent systems, there can be unaccented words. In Tokyo Japanese, for example, words can be accented or unaccented (Kubozono 2011). The accented words realize the accents in terms of a high pitch pattern and unaccented words have a default pattern (resulting from a so-called boundary tone). Unaccented words in pitch-accent systems are remarkable because, stress-accent languages do not have them. In English, there are no nouns, verb or adjectives that are unaccented (assuming that each stressed syllable bears an accent). This issue raises the question whether accent is necessarily obligatory in pitch-accent systems (which it apparently is not in Tokyo Japanese).

In addition to stress or accent and tone, there are additional causes for observing prominence cues within words. Firstly, we can have *rhythmic alternation* with rhythmic beats.[19] Research in word rhythm has revealed that languages follow different rhythmic patterns which have led to the development of so-called foot typologies (see Hayes 1995; van der Hulst 2000). Rhythmic structure can be combined with stress-accent, which is then often called primary or main stress. Secondly, the perceived prominence within words can be the result of phrase-level rhythm (Roca 1986). Since phrasal accents can be anchors for intonational tone units (following Bolinger 1978 often called pitch accents), the apparent perception of word-level stress can be caused by the fact the words, while lacking their own accent, are in a position where they carry the phrasal accent and its associated tonal specification (see Gordon 2014). Finally, the perception of word prominence can be the result of properties that are associated with edge of domains bigger than the word (such as boundary tones, phrase-final lengthening and so on).

Despite all the ingredients, as just discussed, that go into the perception of word prominence, most typological studies focus on the location of what is most often called 'primary stress', frequently providing few phonetic details of how the 'stress' is realized (see Greenberg and Kashube 1976 and Hyman 1977 for early studies).



A: stress located on one of the leftmost two syllables
B: stress located on one of the rightmost two syllables
C: stress located on left word edge, but not restricted to leftmost two syllables (two languages only)
D: stress located on right word edge, but not restricted to rightmost two syllables; or stress located on either penult or antepenult (never final).
E: stress may be located on any syllable in the word (unbounded).
F: combination of C or D and E.
G: stress location is not predictable/cannot be determined; it is either lexical, completely irregular, or there is no primary stress (all stresses are equally prominent).

Figure 2.1 Stress types in QI (top) and QS (bottom) languages (from Goedemans 2010: 654, 655)

Figure 2.1 displays the numbers from a sample taken from Stresstyp for primary stress location in systems with fixed weight-insensitive and variable weight-sensitive accent (Goedemans 2010: 652, 655):

Visualization can also take the form of maps. Quite often, just plotting the values of a certain parameter on a map for a good-sized sample of the world's languages will reveal striking *areal* patterning. This enterprise was undertaken on a large scale by the *World atlas of language structures* project, for which StressTyp was the source for four chapters (maps) on stress patterns in which Goedemans and van der Hulst (2005a, 2005b, 2005c, 2005d) and Goedemans (2010) provide typological information based on

the StressTyp database which differentiates primary stress location, rhythm types and weight factors. Since StressTyp contains quite a few fields, one could easily provide figures for many more parameters, as well as parameter combinations.

In this section reference has been made to the notion phrasal stress or stress accent. Less typological work is available on prominence profiles of domains larger than the word. The location of the phrasal accent can be quite complex in some languages (such as English and other Germanic languages) or quite simple (as in Romance languages), but sufficient cross-linguistic research in this area is missing, making it difficult to state typological generalization. I refer to Hirst and DiCristo (1998) and Ladd (2009, Chapter 6).

There are many case studies of stress systems and various works that collect information about large numbers of languages. Van der Hulst et al. (2010) provide broad overviews of stress systems in all parts of the world. Hayes (1995) provides analyses of a wide variety of systems, as does van der Hulst (forthcoming). The StressTyp database, which is constantly updated, contains information about stress and accent in over 700 languages. Stress information can also be found in the Lyon-Albuquerque Phonological Systems Database (the newest version of UPSID).

2.6 Tone

Students of lexical tone have always been interested in typological issues. There is considerable diversity along various parameters. The defining characteristic of a tonal language is that pitch is used distinctively at the syllable (or mora) level.[20] When tone is distinctive at the syllable or mora level, we can be dealing with an H/L contrast (possible to be interpreted as an H/zero contrast), or we can have multiple tones contrasting with each other (always allowing for zero to be one of the 'options'). In the prototypical tone language, the relevant tonal contrast can be attested for each tone-bearing unit (Pike 1948). In actual languages with polysyllabic words, often various restrictions are in place. In H/L (or H/zero) systems, it is quite common for there to be some restrictions on the occurrence of H tones in polysyllabic morphemes or words such that contrast *cannot* occur on each syllable (see van der Hulst 2011; Hyman 2006, 2007a, 2007b). When restrictions are so dramatic that, effectively, only one H is allowed to occur per word, we transition from a (restricted) tonal system into an accent system.

In addition to H and L, some systems may have a so-called mid tone, or even two mid tones (high mid and low mid), with a four-way distinction being close to the maximum.[21] H, L and M are called *level tones* and these can be opposed to so-called *contour tones* (falling, rising, even

falling-rising or rising-falling). In autosegmental analyses contour tones are analysed as sequences of level tones, but it remains to be determined whether all contour tones have the same representation (see Gordon 2001). There appear to be typological differences that correlate with certain linguistic areas. Asian tone languages make frequent use of contour tones and can therefore have very rich tonal systems, since contour tones always occur in addition to level tones. African languages rarely use contour tones contrastively, although such tones can arise in the course of a phonological derivation, due to tone spreading, for example. In the Mesoamerican area we also find many tonal languages. A common pattern here is that tone combines with stress accent; Suárez (1983) mentions Northern Pame and Yaitepec Chatino as languages that have a tonal contrast only in the syllable that is said to be stressed' (which is the last syllable in both cases), often leading to the dependency that tonal contrast occurs, or is richer, only in accented syllables.[22]

Sources for tone systems are Maddieson (1978), Weidert (1981), Yip (2002), Hyman (2001) and Zhang (2002). Maddieson (2005c) provides maps. We refer to Gordon (forthcoming, Chapter 7) for further details. Database sources for tonal distinctions are the extended UPSID and also Xtone (constructed by Larry Hyman).

2.7 Prosodic Domains

Duality of patterning does not just mean that morphemes are phonologically structured in terms of phonemes, syllables and feet. Duality of patterning is a property of *all* linguistic expressions, including complex words, phrases and sentences. Within generative grammar a complete *phonological hierarchy* (usually called the *prosodic hierarchy*) has been proposed going from syllables, to feet, to phonological words, clitic groups, phonological phrases, intonation phrases and so-called utterances; see Nespor and Vogel (1986), Fox (2000) and Grijzenhout and Kabak (2010a). Properties of this hierarchy, above the level of the simplex words, were seen as being dependent on the morphosyntactic structure. In the section on stress, we already referred to foot structure. In this section, I refer to studies of domains above the foot level, starting with the prosodic (or phonological) word. But first we must note that prosodic domains play multiple roles in phonological systems. As we have seen, such domains are relevant for locating prominent syllables (heads of feet, indicating rhythmic stress) or within the word or the phrase (indicating word and phrasal stress).

Turning now to the typology of prosodic or phonological domains, we start with a word of caution. Van der Hulst (2009) discusses literature in which it is suggested that we need to distinguish between two

phonological hierarchies, one 'deep' and one 'shallow'.[23] For the sake of the present discussion, we will call the former the *phonological hierarchy*, whereas the latter will be called the *prosodic hierarchy*. Clearly, typological studies need to be explicit concerning which levels they are addressing. Van der Hulst shows that when studies refer to notions such as syllables or feet, it does not always make explicit whether the terms used refer to deep or surface units. When avoiding making this distinction, I will simply speak of 'P-hierarchy', the P-word, etc.

In the original proposals, the P-hierarchy is strictly layered, which means that a unit of type T contains (two) units of type T-1. This excludes *recursive structure* in which a unit of type T contains a unit of type T. We will see below that there is, in general, a trade-off between allowing additional layers in the hierarchy and allowing (a limited amount of) recursion.

Vogel (2008) offers a general typological perspective on the P-hierarchy. Individual layers have been subject to (limited) typological studies which we will review in the upcoming sections. Broad typological studies (based on large numbers of languages forming a representative sample) have not been carried out, and one reason for this is that it has proved difficult to arrive at generally accepted definitions of prosodic domains. I suspect that it is, in part, due to the above-mentioned ambiguity of P-hierarchy and its domains.

2.7.1 P-words

The P-word has attracted considerable interest. The main problem lies in its definition.[24] While simplex words are uncontroversially P-word and compounds generally form two P-words, it is not obvious how words that contain affixes are mapped onto the P-word domain. It would appear that not all complex words that contain affixes form one P-word, which is to say that some affixes can be included while others are excluded. When looked at from a cross-linguistic viewpoint, it is not at all simple to determine unambiguously what in any given language constitutes a P-word. Basing themselves on a database that encodes the domain of phonological processes in sixty-three languages, Bickel, Hildebrandt and Schiering (2009) demonstrate that in many languages different phonological processes, even within a single language, refer to domains that correlate with different types of morphological constructions. While some of these domains may be illusory because the processes in question are tied to specific morphemes and, as such, do not warrant the postulation of a domain, and also allowing, as suggested in Vogel (2009: 21) straightforward exceptions, it would seem that genuine phonological processes do not always all refer to the same domain. Bickel et al. (2009) observe that the domain that is relevant for stress tends to be the most inclusive domain. It might be suggested that a uniform definition (at least per language) of

the P-word can be obtained if we come to recognize the fact that there are, in fact, two phonological hierarchies, one deeper and the other more shallow. In this view, the fact that stress regularities tend to correlate with more inclusive domains might be caused by the likelihood of regular stress to be located at the more shallow utterance level, which would allow it to be more inclusive, by, for example, embracing clitics.

In order to advance the typological study of word domains, it is necessary not only to locate processes that are taken as diagnostics at the right level but also to include extensive study of languages that have very different types of morphological systems, including highly agglutinative and polysynthetic systems (see Dixon and Aikhenvald (2002a, 2002b).

2.7.2 Clitic Groups

The clitic group was a later addition to the prosodic hierarchy.[25] While it is clear that units called clitics typically cohere with a host by forming a phonological unit, this unit cannot be a P-phrase because P-phrases are supposed to dominate entities that qualify as independent P-words. The original proposal was that clitics cohere with preceding or following P-words, forming a new domain (that is distinct from the P-phrase) which is not subject to processes that apply to the P-word or P-phrase, but might display processes that are exclusive for this intermediate domain. A typical example would be to observe a special stress rule that places the stress in the P-word host on its final syllable. A classical example of a pre-accenting clitic is the unit *-que* 'and' in Classical Latin. Peperkamp (1997) also shows that the domain formed by adding clitics can correlate with special stress phenomena, but instead of adding a clitic group to the hierarchy, she allows the P-word to be *recursive*.

2.7.3 P-phrase

As shown in Grijzenhout and Kabak (2010b), there have been many proposals to add new domains to the prosodic hierarchy in between the word and the intonation group in addition to the clitic group. Originally endowed with one phonological or prosodic phrase, several authors have proposed different types of P-phrases (at the same level). Grijzenhout and Kabak remark (p. 3): ' it is often not clear whether the variation we observe is due to distinct phonological phenomena, typological diversity, or different research practices in the field'. To this we might add that some authors have proposed that processes at the phrasal level make direct reference to syntactic phrases (see, for example, Seidl 2001), thus bypassing the postulation of prosodic domains altogether, or at least postulating a deeper phonologically relevant structure that is close if not identical to the syntactic structure. Since

syntactic structures are generally not required to only provide nodes for overt lexical material, it is often possible to accommodate phonological processes in the syntax.

2.8 Intonation

While intonation is often regarded as a 'phonological' phenomenon, it is clearly much more than that. The intonational system of a language forms a grammar in its own right that characterizes 'melodic' expressions that are co-orchestrated with syntactic expressions. As such intonational systems have their own lexicon of tonal units (pitch accent, boundary tones) in which entities have a phonological *and* semantic/functional specification. These tonal units combine to form tonal strings according to a combinatorial (indeed 'syntactic') system which has a compositional semantics. In other words, full utterances consist of a 'text' (the words) and a 'tune' (the tonal units); see Gussenhoven (1984).

In a volume that collects work on the intonational system of a wide variety of languages, Jun (2005: 430) writes: 'Studies on prosodic typology are rare probably because prosodic features are not easy to define and categorize, and also because prosodic features of languages have been described, if at all, with different assumptions and within different theoretical frameworks.' What is still needed is a large representative collection of studies. Clearly, such a collection is much more difficult to construct than one characterizing phoneme inventories or syllable types (which by themselves are by no means easy, as we have seen). One issue is that detailed information about intonation systems requires descriptions and analyses by native speakers, since otherwise, judgments about the linguistic and paralinguistic relevance or pitch patterns are very difficult to obtain (see Hirst and Di Cristo 1998a: 2). New typological studies have to be based on analyses of individual languages which are often carried out within very different approaches and notational systems. An early typological study of intonation is Bolinger (1978).[26] Fortunately, to provide the groundwork for intonational typology, various projects have been undertaken to collect detailed analyses of a broad variety of languages. In this spirit, Hirst and Di Cristo (1998b) contains descriptions and analyses of twenty languages (thirteen of which are Indo-European languages). The editors realize the importance of a uniform notational system and they propose INTSINT (International Transcription System for Intonation), which provides symbols for pitch rises, falls and so on. Another such cross-linguistic collection is offered in Jun (2005, 2014), two volumes that contain analyses of intonation systems in a wide variety of languages.[27] Fróta and Prieto (2015) contains analyses of intonation in nine Romance languages; Gussenhoven (2004) and Riad

and Gussenhoven (2007) also offer mostly studies of intonational systems of a variety of languages. In all these volumes, comparison is facilitated by the fact that many authors have adopted the autosegmental-metrical framework (Gussenhoven 2004; Ladd 2009). Another unifying force is the ToBI system (a notation system for 'tones and break indices'; see Beckman, Hirschberg and Shattuck-Hufnagel 2005).[28] It is to be expected that cross-linguistic work on intonation will increase as many more analyses of intonation systems have been carried out in the autosegmental-metrical system.

2.9 Rule Typology

Phonological generalizations can be grouped in types along at least five dimensions. Firstly, it is necessary to consider the *level* at which the generalizations apply. Secondly, generalizations fall in two categories depending on whether they express *static* (or phonotactic) regularities or *dynamic processes* that change representations. Thirdly, with specific reference to dynamic processes we need to consider the *type of formal operation* that is involved (insertion, deletion, assimilation or spreading, etc.). Fourthly, we can classify processes in accordance with the *feature or feature class* that is involved and finally, we can look at the particular *domain* that the generalization pertains to. Most typological studies focus on a particular type of process, either in general or with reference to specific features.[29]

Dynamic phonological generalizations can also be classified in types depending on level, which implies a typology of rules in three classes: phonetic/allophonic processes, 'proper' phonological rules and morpholexical/alllomorphic rules (van der Hulst 2016). For each of these three types, divisions can be made along the line in (19). Specific attention has been given to a further classification of morpholexical rules (Dressler 1985; Inkelas 2014, Chapter 1). Paster (2006) deals with phonological conditioning of affixation and a typology of phonologically conditioned suppletive alternations is offered in Nevins (2011).

2.10 Typological Correlations or 'Co-variation'

2.10.1 Holistic Typology

Studies that target a single property of phonological systems (including frequency information) are very useful because they fuel the development and testing of theoretical proposals bearing on specific areas of phonology. As we have seen, research in the Greenberg tradition is focused on this type of work, even though attention has also been paid to unidirectional

implicational relationships. However, an additional dimension of typological work (perhaps a crucial dimension for many European typologists) is to establish *correlations* (i.e. bidirectional implications) between different variables and to then also explain these. While correlations between morphology and syntax are to be expected, given that both systems deal with the hierarchical combination of meaningful units, making use of similar structures and mechanisms, we do not perhaps expect that either system will display systematic correlations with phonology, which after all accounts for sound structure *an sich*. However, there is a long tradition in typological research that aims at grouping languages into basic types with manifestations of being one type or another in all areas of the grammar. In this tradition it is usually claimed that a language's 'ground plan' is foremost a phonological one. Both Auer (1993) and Plank (1998) present reviews of claims regarding co-variation of phonology with morphology and syntax. The latter author presents a thorough review of this idea that goes back to the eighteenth century. Both authors pay considerable attention to more recent proposals by Gil (1986) and Donegan and Stampe (1983).[30] Both studies correlate stress location bias with syllable complexity and word order, among others, but surprisingly in opposite manners. Gil correlates trochaic bias with smaller (less complex) syllable types and SOV word order, whereas Donegan and Stampe make the opposite correlation. Another related typological classification, also discussed by Plank, but a focus in Auer is the dichotomy between stress-timed and syllable-timed languages. This classification, as Auer documents, did not, like the previous proposal, pretend to be holistic in that it was not claimed to correlate with syntactic differences. There is a considerable body of literature on this division, and the central claim, namely that in stress-timed languages the interval from stress to stress is equal, irrespective of the number of syllables that go into a 'stress foot', has proved to be false (see Dauer 1983). Nor is it the case that in syllable-timed languages all syllables have the same duration. The interest of Auer's work is that he proposes to replace this specific proposal by another proposal which expresses the idea that there are 'word' and 'syllable' languages.[31] In the former, the word is a central organizing unit in phonology, both in phonotactic terms and in terms of processes, while the syllable is the pivotal unit in syllable languages.[32] The following table summarizes some of the major distinguishing criteria for the two types of languages:[33]

(18)

	Syllable	Word
reduction of non-accented syllables	NO	YES
contrastive length	all syllables	only in accented syllables

tone	all syllables	only in accented syllables
syllable structure[34]	simple	complex
syllable division	clear	not always clear
assimilations	few	many
word-relation processs	no	yes
vowel harmony	possible	non-possible
word accent/stress	predictable	morpho-lexical

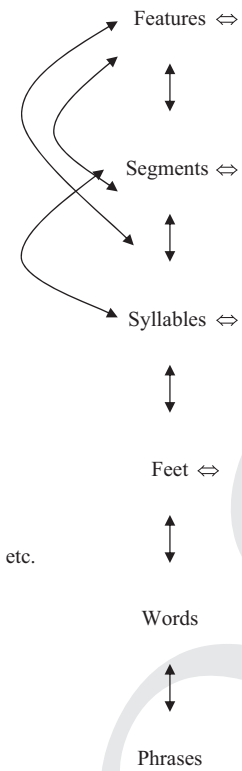
Auer examines thirty-four languages in some detail and concludes that the word/syllable division is a gradual one, with some languages coming close to being ideal types, while others possess properties of both. All in all, words are clearly demarcated units in word languages, marked as such by special phonotactic options at edges and strong word stress with subordination of unstressed syllables.

Before concluding this section, we also need to briefly mention co-variance between phonological form and meaning. Recently, there has been renewed interest in the idea that de Saussure's arbitrariness claim fails to do justice to the fact that in many languages significant systematic correspondence exists between form and meaning at the lexical level. One type of correspondence is referred to as iconicity (Perniss, Thompson and Vigliocco 2007), but form–meaning 'resemblance' is one instance of the broader phenomenon of *ideophones* (as understood in Dingemanse 2012). Non-arbitrary form–meaning relationships are widespread in sign languages (see among others Meir et al. 2013), but as both Perniss et al. (2007) and Dingemanse (2012) make very clear, there is good reason to reconsider their rarity in spoken languages. This means that phonological typological research must include in its scope the typology of systematic form–meaning correlations.

2.10.2 Intramodular Correlations

While cross-modular correlations continue to be controversial, despite recent work that is based on more solid empirical grounds,[35] intra-modular co-variance is more likely to be less controversial, as well as more easily testable. Establishing co-variation between different aspects of phonology is important because it either points to a missing theoretical link between these two aspects or can lead to rather more drastic revisions in the theory. In this section, which is primarily meant to be programmatic and as such suggestive of further typological research of this correlative kind, I make a distinction between correlations *within* layers ('⇔') of the phonological structure and between different layers (←→); interlayer correlations can hold between adjacent layers or non-adjacent layers:

(19)



This scheme indicates logical possibilities for (correlative) typological research. I believe that this scheme is useful, on the one hand, to locate specific correlative typological studies and claims that have been made in the phonological literature[36] within this logical scheme and, on the other hand, to identify other plausible correlative case studies that have not yet been undertaken.

In this section I cannot illustrate all the possiblities that are implied in this schema, so I will limit myself to a few examples.

At the level of feature, one might ask whether there is a correlation between features that are active for both consonants and vowels, assuming, as many phonologists do, that there is a single set of features that generalizes over both classes (see, for example, Jakobson, Fant and Halle 1952; Anderson and Ewen 1987; Clements 2009). This particular expectation is reasonable, since it *is* the case that features are similar across subsets of vowels and subsets of consonants. The result seems to be negative (see Hauser 2012). If no such economy exists *across* consonants and vowels, this perhaps calls into question the fact that both sets draw on a single inventory of vowels.[37]

Moving from the features to segmental inventories, one might ask whether there are intralayer correlations between vowel and consonant inventories. An obvious (and indeed often asked) first question is whether there is an (inverse) correlation in the size of these inventories.

While the expectation that this would be so seems plausible perhaps, there are, in fact, no significant correlations of this type (see Maddieson 2007). Large consonant sets do not imply smaller vowel sets and vice versa.[38]

Next, we can consider interlayer correlations between segment inventories and the typology of syllable structures of languages, first focusing on the notion of complexity. We have seen that languages differ in terms of their inventories of permitted syllable types. Do languages with simpler syllables have larger inventories of vowels and/or consonants? Intuitively, one might expect that larger segment inventories correlate with simpler syllable structure. With 5 vowels and 10 consonants there are 50 possible CV syllables, while 10 vowels and 20 consonants drive this number up to 200. Both numbers would vastly underrepresent the total number of required morphemes. To increase the number of possible syllables (and thus morphemes), one can increase the number of phonemes or the complexity of syllable structure (or both). Even with a fairly modest phoneme inventory, many possibilities emerge when allowing syllable structures that are sufficiently complex (CCVC = 8,000; CCVCC = 160,000), presumably enough to represent a 'decent' lexicon. If the number of phonemes and syllable complexity were the only two variables that matter, one would expect an inverse correlation. This expectation is difficult to test because there are other ways for increasing the number of morpheme shapes. A language can increase complexity along the syntagmatic axis of polysyllabicity (by allowing CVCV, CVCVCV and so on). Both increasing syllable complexity and increasing the number of syllables lead to longer morphemes. Maddieson (2007) studies the correlation between phoneme inventory size and syllable complexity. I am not aware of a study that correlates phoneme inventory size with polysyllabicity. However, since both strategies suggest that there will be a correlation between the number of phonemes and the length of morphemes, there is one study (Milewski 1973) that bears on this correlation (which is strictly speaking an intermodular correlation if morpheme structure is an aspect of morphology). Meanwhile, we must note that there is a third way to increase the morpheme inventory while keeping syllable complexity and combining syllables modest, which is to increase complexity along the paradigmatic axis, for example by adding a tonal dimension. This suggests a place for the study of correlations between syllable structure and/or segmental inventories (with particular attention to tonal features).[39]

As another example, I will now consider the correlation between syllable types and foot structure type (or, more generally, stress type). As we have seen in section 2.5 (on stress), typological studies within the metrical tradition have distinguished between many foot types (notably iambic/trochaic; weight-sensitive/weight-insensitive; various types of weight-sensitivity; bounded versus unbounded systems). In this tradition various claims have been made about the presence of such foot types and the kinds

of syllable structures that languages allow (including vowel length as a property of syllable structure). Trivially, weight-sensitivity is impossible in a language that only allows CV syllables.[40]

A much discussed typological distinction involves the so-called *iambic-trochaic law* according to which grouping of units of equal weight (syllables or morae) correlates with trochaic feet, while grouping of units that differ in weight (specifically in terms of vowel length) induces iambic grouping.[41] This law suggests that the type of rhythm, as well as whether or not footing is weight-sensitive, correlates with the syllable structures that a language permits. A specific example of the correlative study of syllable weight type and stress type is Ahn (2000), who suggests that unbounded stress systems correlate with having CVV heavy syllables.

Here we can also consider correlations between foot structure and word structure. Does having a specific kind of foot structure have bidirectional implications for word structure? A potential example would be that left-headed feet would correlate with left-headed words. No such correlation has been noted. Another possibility would be that the type of foot is correlated with the direction of foot assignment. This correlation has been noted. Whereas the initial idea of metrical theory was to cross-classify all parameter settings into a classificatory typology (a multidimensional matrix of all combinations of settings), subsequent research showed that certain predicted cells in this matrix did not fill up as much as other cells. In particular Hayes (1995) established that there are some serious data gaps in so-called iterative systems (LR = left-to-right in (20)):

(20) Data gaps
  a. Right-headed (Iambic)/weight-insensitive: rare in either direction
  b. Left-headed (Trochaic)/weight-sensitive: absent LR

Rather than somehow explaining these correlations between parameters, based on these findings Hayes proposed a revised theory of foot types; see van der Hulst (2000) for a detailed account of various versions of foot parameters and their virtues.

Another interesting correlation is that between direction of foot assignment and the location of the head foot (i.e. the one expressing primary stress). It was noted in van der Hulst (1984) that LR direction correlates with left-edge stress, while right-to-left (RL) correlates with right-edge stress. This correlation was then taken to suggest a modification of the theory in which the assignment of primary stress takes precedence over rhythmic foot assignment (see van der Hulst 1996, 2014).

2.10.3 Co-variation between Structure and Rules

In addition to units in the P-hierarchy, phonological systems also contain a derivational component. We could thus also consider correlations *within*

the derivations component or correlations between aspects of the representational system and specific rule types. A first question regarding the derivational aspect of phonology that should be asked, however, concerns the correlation between deep prosodic structure at the phonemic level and surface prosodic structure at the utterance level, given that this distinction mentioned in section 2.7 is made. For example, do both levels use the same foot structure? While it may seem reasonable to expect that this is so, we have to reckon with discrepancies, which lead to what we could call 'metrical incoherence' across levels. For example, Gordon (2014) discusses cases in which deep foot structure differs from surface foot structure, presumably as a result of the former reflecting an older phase of the language. Likewise, we could ask about the inventories of phonemic and phonetic syllables. Systematic relations between syllable structure at both levels might involve the relative complexity of consonant clusters and the attachment of intervocalic consonants. Correlations between segmental inventories at both levels are expressed in terms of allophonic rules. Thus, a correlative typological study could target the array of likely allophones that phonemes have.

We can also investigate correlations in the occurrence of phonological rules or processes. Sometimes various processes are likely to co-occur within a phonological system because they conspire to achieve a certain output. For example, at the phonemic level, various rules might conspire to avoid syllables that exceed the complexity that is allowed, when such complexity violations arise from morpheme concatenation. The phonology of Yolumne (formerly Yawelmani) provides a well-known case of such a conspiracy (see Kisseberth 1970). The fact that one phonotactic constraint can be served by a number of different (repair) processes opens the door to typological studies of repair processes; why some are more likely to occur than others.

Another source for correlations can be established by considering types of prosodic structures and types of rules. A well-known example is the frequent occurrence of vowel lengthening in iambic systems (see Hayes 1995). In the domain of vowel co-occurrence restrictions, a distinction is often made between vowel harmony (which supposedly has an RL bias) and umlaut (which has an LR bias), which is then said to correlate with the type of accentual system (van Coetsem 1996).

Finally, I mention the potential correlation between the structure of the vowel inventory and vowel harmony. In several articles, Casali (e.g. 2003, 2007) has argued, based on a typological study of 110 African languages, that dominance of [+ATR] is only attested in systems with two series of high vowels (one advanced and one non-advanced; 2H-systems), whereas dominance of [−ATR] is highly typical of 1H-systems. He

mentions only few exceptions. We can summarize Casali's finding as follows:

(21) Casali's correlation
2H ~ [+ATR] dominance
1H ~ [–ATR] dominance

This is a good example of a systematic correlation between the structure of inventories and the type of harmony processes.

2.11 Concluding remarks

In this review of typological research in the area of phonology, I have tried to distinguish a variety of different angles and approaches, focusing more on the nature of each than on quantitative results. The field of phonological typology is still dominated by quantitative studies of segmental inventories and stress systems. Systematic studies of syllable structure types that can rely on careful analyses of individual languages are missing, although some results on the phonotactics of specific consonant clusters (such as onsets clusters) are available. For higher levels of P-structure, comparison across large sets of languages is largely also missing, although there has been significant progress in the study of P-words and intonational systems. We have seen that correlative typological studies with holistic aims have led to claims that are sometimes contradictory and often speculative. I have finally tried to lay out a systematic programme of intraphonological correlative studies, referring to some such work that is available as well as work that could be undertaken. Work of this kind is particularly important for the further development and refinement of phonological theories.

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Notes

1. Both Velupillai (2012) and Moravcsik (2013) give phonology due attention, the former based on the information in the online version of *The world atlas of language studies* (WALS). Haspelmath et al. (2005) have

19 (out of 142) chapters on phonology. Song (2011) has one chapter on phonology. A welcome and very useful addition to the literature on phonological typology is Gordon (forthcoming), a book-length contribution with separate chapters on inventories, syllables, stress, tone, intonation and prosodic templates. Phonological typology targets many other areas of phonology such as language historical change (Kümmel 2015), first language acquisition (Dinnsen and O'Connor 2001).), second language acquisition (Altmann and Kabak 2011), pidgin/creole languages (Klein 2011), loan phonology (Kang 2011), language games (Bagemihl 1988), speech errors (Fromkin 1973; Frisch and Wright 2002), speech disorders (Dinnsen and Gierut 2008), reduplication (Moravcsik 1978; also see the Graz Database on Reduplication). Many articles of typological interest can be found in various handbooks in phonological theory (such as Goldsmith 1995; de Lacy 2007; Goldsmith, Riggle and Yu 2011; Kula, Botma and Nasukawa 2011 and in particular Oostendorp et al. 2011, which contains 120 long chapters each offering overviews of a different area of phonology).

2. The Stanford University project on language universals (1967–1976) produced many more studies that were published in the *Working Papers in Language Universals*.
3. This typological trend in phonology is continued and intensified in Optimality Theory (OT) (Prince and Smolensky 1993; Kager 1999), which has replaced parameter setting by constraint ranking. Both formal methods (parameters or constraints) predict typologies (i.e. what is possible according to these models), and the task of researchers is to then establish which of the predicted possibilities occur. However, given the great number of constraints being proposed (compared to much more limited inventories of parameters in earlier work), OT can account for much more fine-grained typologies. The set of possible systems that is predicted by a given set of constraints, and all possible rankings of these, is called a 'factorial typology' in OT works. See Gordon (2007) for typology within OT.
4. For other surveys of phonological typology, see Maddieson (2011) and Schmid (2012). For phonetic typology see Maddieson (1997).
5. The problems that are involved in establishing phonemic distinctions from descriptions are discussed in Maddieson (1984) with reference to the construction of the Universal Phonological Segment Inventory Database (UPSID)
6. The view that features are innate has been questioned in Mielke (2008).
7. In element approaches (Kaye, Lowenstamm and Vergnaud 1985; Anderson and Ewen 1987), it is typical to postulate a very small set of primes (that, then, have multiple phonetic correlates). It then is more likely to find that all languages employ all elements. Note that this

theoretical perspective invites typological research into the potential cross-linguistic variety of phonetic correlates of phonological primes.

8. This, however, is not a point of logic. The activity of features can also be indicated by phonological rules/processes. See Clements (2009) for criteria that underlie the recognition of features in general and in any given language.
9. The economy idea focuses on features that are necessary for contrast. Additional features may be used for enhancement of contrast (see Keyser and Stevens 2001). Note again that distinctions of this sort entail further perspectives for typological research, since one can now imagine doing a typological study of enhancement.
10. Here we should note that typological studies of inventories for vowels are typically restricted to vowel qualities, ignoring matters of length, tone or phonation, as well as diphthongs.
11. See Gordon and Applebaum (2006). These languages are known for their rich consonant system containing, among others, consonants with secondary articulations (such as /k^j/ and /k^w/). When vowels occur next to such consonants, they acquire the 'j' and 'w' colours which gives allophones such as /i/ and /u/ for /↑/. At the phonetic level, we can hear a lot of different vowel qualities. One can imagine having a debate as to whether the vowel system would be more complex with the secondary articulation on consonants coming from the vowels. Historically, at least, this appears to be what happened in some languages that have a vertical vowel system.
12. The notion of dimensions is somewhat similar to the notion of feature classes, proposed in Anderson and Ewen (1987) and Clements (1985).
13. We must note that the idea of dimensions is also relevant for vowels. While vowels can be lexically contrastive in terms of nasality or phonation, such properties do not show up in small vowel inventories and corresponding implications obtained.
14. Crothers (1978) studied 209 languages (balanced for language family and geographical area), Schwartz et al. (1997) is based on a larger corpus.
15. All reviews of vowel and consonant systems have clearly indicated that certain phonemes are more likely to occur in systems than others. Thus, among vowels, /i/, /u/ and /a/ have a high cross-linguistic frequency. It is interesting that the high cross-linguistic frequency of these phonemes is matched by a higher frequency within languages that have these, but also other phonemes. I refer to Gordon (forthcoming, Chapter 3) for examples and discussion of typological generalization concerning inventories both across and within languages.
16. Languages of Type 1b sometimes impose the constraint that they do not allow hiatus.

17. The sonority scale is also referenced by generalizations about so-called lenition and fortition processes, which move segments up or down the scale, so to speak.
18. Articles that propose typologies galore: Hyman (2006), Goedemans (2010); see van der Hulst (2011, 2014) for typologies and additional references.
19. Note that when using stress as a phonetic cue, we can say that stress is a cue of both the unique accent and rhythmic beats.
20. We have seen in the preceding section that tone can also be contrastive at the morpheme level, as in Tokyo Japanese.
21. Cases in which five level tones or more are distinguished are rare. See Donohue (1997) and Edmonson, Bateman and Miehle (1992).
22. In these languages tone location is dependent on stress. It is also possible that stress placement can be sensitive to the presence of tone (see de Lacy 2002).
23. See especially Rischel (1978) and Lahiri and Plank (2010). The same idea is suggested in Auer (1993: 90).
24. See Hall (1999), Hall and Kleinhenz (1999), Peperkamp (1997), Vigário (2003), Hildebrandt (2015) among others. See Dixon and Aikhenvald (2002a, 2002b) for a general consideration of the notion word, in both a morphosyntactic sense and a prosodic/phonological sense. Also see Dixon (2010: 1–36) for a list of criteria for how to distinguish phonological words from grammatical words.
25. A comprehensive discussion of the pros and cons of the clitic group can be found in Aikhenvald (2002). See Aikhenvald 2002 and Vogel (2009).
26. Several other works contain typological comparisons: Fox (1985, 1995, 2000), Ladd (2009). See also Gordon (forthcoming, Chapter 7).
27. In the paperback edition of the second volume, Jun supplies a list of websites with ToBI systems and application for a variety of languages. She also mentions various conferences and resulting publications in the area of intonation during the first two-thirds of the 2000s.
28. These authors characterize INTSINT as a narrow transcription system as opposed to the broader ToBI system. Another difference is that INTSINT does not encode prosodic boundaries.
29. P-base is a database of phonological processes in 600 languages.
30. Donegan and Stampe's proposal is based on (and limited to) a study of Munda and Mon-Khmer languages. Gil's study is based on a bigger sample of 170 languages, drawing data from the Stanford Phonology Archive and UPSID.
31. See also Caro Reina and Szczepaniak (2014) on the typological distinctions between syllable and word languages (and their introduction to this volume (pp. 8–42; as well as Auer's preface).

32. Auer also discussed Pulgram's (1970) somewhat similar (albeit different in many details and scope) suggestion that languages can be classified according to the size of the central phonological unit.
33. Van Coetsem (1996) also developed a typology based on type of accent and correlations involving the presence of vowel harmony or umlaut.
34. Nespor, Shukla and Mehler (2011) discuss the role of syllable complexity as a particularly important diagnostic (if not a defining property) of the distinction between syllable- and stress-timed languages.
35. See, for example, Tokizaki (2008).
36. Such work is often not presented as being 'typological', because many researchers associate typology with frequencies of individual phonological properties, rather than with the likelihood of correlations.
37. The theory proposed in Chomsky and Halle (1968) is of this kind. In elements theories with very small sets of primes, shared by consonants and vowels, which, because there are so few, are likely to be active in all languages, it is almost necessarily the case that both consonants and vowels draw on the same set. In this case, we would explain difference between vowels and consonants in terms of different phonetic correlates of elements, mostly due to the fact that vowels necessarily lack contact stricture, while consonants are almost always defined and distinguished from vowels in having contact stricture.
38. Maddieson (2005c: 19): '[T]he occurrence of a large consonant inventory with a small number of vowel distinctions is not part of a general pattern in languages but reflects a geographically restricted tendency that can be found in a few areas (primarily in southern Africa, the Caucasus and the American north-west).'
39. This could be construed as an interlayer correlation that regards non-adjacent layers (i.e. features and syllables).
40. Although this would still allow for weight-sensitivity depending on vowel aperture/sonority.
41. There is an extensive literature on this correlation; see Hyde (2011).

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