

Phonemes – rules & representations – phonological processes – prosody

A general introduction to phonology

A. Phonetics...

- independent of particular languages
- data of general phonetics is *observable*
- phonetic studies can produce *new facts* which can contribute to our phonetic knowledge

...vs. phonology

- dependent on particular languages
- object of investigation not always directly accessible
- cannot produce new concrete *facts*

Phonetics studies the articulatory and physical properties of speech sounds (as well as the perception and processing of speech sounds in the brain) language-independently while phonology studies the various ways in which speech sounds (now as **segments**) are organised into **systems** of different languages. The *goal* of phonological theory is to develop a universal framework that will reflect and account for the capabilities of the language speaker.

B. What is phonological knowledge?¹

- Segmental knowledge (consonant and vowel system) of language X
- Phonotactic knowledge (possible combinations of segments) in X
e.g. - sp, st, sk : illegal in syllable-initial position in Spanish but OK in English
- complex onsets are OK in English but not, say, in Rennellese (a Polynesian CV language)
- Prosodic knowledge (stress and syllable structure) of language X
- Morphophonological knowledge of language X (how different can two forms of the same word be in Language X? e.g. [ˈʃeri] / [ˈʃerka] in Cypriot Gk).

C. The phoneme

The concept of *distinctiveness* in phonology

If two sounds, however similar they may be phonetically, *contrast* in a given language they constitute two distinct *phonemes* of that language. Elements of a

¹ Acknowledgement for this section (what is phonological knowledge?): Dr. Stephen Parkinson, Oxford University.

phoneme system (=phonemes) are therefore distinct from each other and capable of differentiating word meaning:

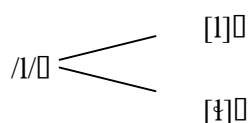
e.g. /pɪn/ vs. /bɪn/ (English)
 /'kano/ vs. /'xano/ (Greek)

The above examples have two distinct meanings (each pair) and differ in respect of one segment (**minimal pair**) only. We can therefore say that /p/ & /b/ and /k/ & /x/ are capable of contrastive function in English and Greek respectively and therefore constitute two distinct phonemes in English and Greek respectively.

If two sounds do not contrast in a given language and the linguistic context predicts which of the two will occur they are **allophones** of the same phoneme in that language:

e.g. ['fi:tʃ], feel
 ['fi:lɪŋ], feeling

In Standard British English the final consonant of 'feel' is pronounced differently from that of 'feeling'. The former is **velarised** or '**dark**' and the latter is '**clear**'. It is nevertheless completely predictable which of the two will occur in a given context in Standard British English: the clear one occurs *before a vowel* and the dark one *elsewhere*. We take [ɹ] and [ɹ̠] to be **allophones** of the same phoneme in E.:



D. Phonological systems

Apart from distinctiveness, a phoneme system of a natural language is characterised by some symmetry in its phonemes:

e.g. the English obstruents (stops/plosives, fricatives, affricates) are symmetrically arranged in terms of a voiced/voiceless distinction (with the exception of h):

English obstruents

voiceless: p t k f θ s ʃ h tʃ
voiced: b d g v ð z ʒ

Different languages have different phonological systems. Cypriot Greek (a variety of Modern Greek), for example, does not distinguish between voiced and voiceless stops, whereas Spanish, among its obstruents, makes a voiced/voiceless distinction in stops only.

Natural classes and distinctive features

A. 1. Sound Pattern of English (Chomsky & Halle 1968)

In the Sound Pattern of English (henceforth SPE), a phonological form is a *temporal sequence of segments*. Segments are arrayed linearly and represent *time units*: e.g. tan / tank / stank.

Segments are further analysed into more fundamental elements/categories and therefore are portrayed as bundles of *unordered distinctive features*. The distinctive feature theory was conceived and proposed by Jakobson (pre-SPE) but was incorporated in the monumental SPE, although Chomsky & Halle defined features on an *articulatory* rather than an *acoustic* basis.

Below is a list of universal distinctive features (DFs) as proposed by Halle & Clements (1983) (source: <http://www.personal.rdg.ac.uk/~llsling1/Phonology/model/mod.nest.html>):

Feature name	Definition (for positive value)
±SYLLABIC	syllable peak
±CONSONANTAL	constriction at least equal to that of fricatives
±SONORANT	sufficiently open for spontaneous voicing
±CORONAL	blade of tongue raised towards teeth/hard palate
±ANTERIOR	obstruction at or in front of alveolar ridge
±LABIAL	constriction at the lips
±DISTRIBUTED	extended constriction along mid-sagittal axis
±HIGH	body of tongue raised towards palate
±BACK	body of tongue relatively retracted
±LOW	body of tongue drawn down away from roof of mouth
±ROUNDED	protrusion of the lips
±CONTINUANT	constriction allows air-flow through mid-sagittal region
±LATERAL	air stream allowed to pass over one/both sides of tongue
±NASAL	lowered velum allowing air to pass out through nose
±ADVANCED TONGUE ROOT	enlarged pharyngeal cavity (raised tongue body)
±TENSE	more constricted tongue body/root configuration
±STRIDENT	airstream directed against secondary obstruction
±SPREAD	vocal cords drawn apart, aspirated
±CONSTRICTED	vocal cords drawn together preventing vibration
±VOICE	periodic vibration of the vocal cords

e.g. [g]

- syll
+ cons
- cont
- son
- cor
+ back
+high
+ voi
...

The features in question are *physical* and not abstract entities.

Evidence for presence of features from:

² Acknowledgement for DFs section: Ron Brasington, University of Reading.

- 1) the fact that they are perceptible by the human ear (the same word can be interpreted differently from native speakers of different languages)
- 2) systematic nature of alternation patterns

2. Binary vs. unary features

The **binary** character of DFs was conceived by Jakobson, who also contended that a binary system reflected *cognitive organisation*.

A binary feature either has the value '+' or the value '-'. Therefore if a segment is not [+Y] then it is necessarily [-Y]. Nevertheless, this *if-then statement* does not apply to some phonetic parameters such as *vowel height*: a [-low] segment is *not* necessarily [+high]. In recent years *unary/univalent* features have been proposed in the theory:

e.g. the feature [labial] is either present or absent in the representation of a particular segment while the absence of voicing in a [-voice] segment is a property in itself.

3. Why distinctive features?

- 1) they express linguistic contrast
- 2) they enable us to describe '**natural classes**' of segments (sound groupings defined on the basis of their shared features). A relatively small number of contrasts hold in groups of sounds.
- 3) phonological processes can be easily formalised (distinctive features are used to describe forms undergoing processes and environments controlling processes)

B. Deficiencies of traditional SPE model of phonology:

- No **temporal** implications within segment

e.g. tʃ (in languages which treat it as a single segment) was represented as [+delayed release] (=released gradually) as opposed to a non-affricate stop which was represented as [-delayed release].

prenasalised segments (e.g. ^mb, ⁿd etc.) were 'statically' represented as [+prenasalised]

As a result, *dynamic* segments were not very insightfully represented since a traditional SPE model allowed *no feature overlap* (an affricate could not have two opposed values [-cont +cont]).

- **stability of tonal pattern** in languages with dynamic *tones* proved to be problematic

features like [±rise] are incapable of accounting for tonal stability under vowel deletion in languages like Margi (Chadic language – Nigeria):

e.g. □□□□+árì → [Bálarì] □ 'man'
 □ □ fà +árì → [fǎrì] □ 'farm'□

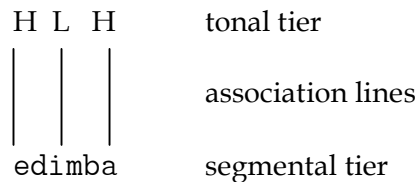
(-árì: definite suffix attached to nouns)

In SPE a *contour tone* could not be represented as [-rise +rise].

-
- failure to capture *naturalness* of phonological processes

C. Autosegmental Phonology

Goldsmith (1976) proposed that tones should be treated *independently* from segments (hence the term autosegmental which refers to the autonomy of features: features are **autosegments**). Tonal melodies should therefore be assigned a separate tier of representation:



Tones are autonomous but of course *co-occur* with sequences of segments. The association lines associate tones with segments. The elements with which tones are associated (= elements that bear tones) are vowels, which are called **tone bearing units** (TBUs).

The association procedure follows specific well-formed conditions:

- associate tones with TBUs from left to right.
- associate leftover TBUs with the last tone
- associate leftover tones with the last TBU
- association lines must not cross.

D. Feature Geometry

The idea of autonomous tonal melodies was later extended to non-tonal features and being combined with the idea that features are grouped into classes gave birth to **Feature Geometry** (Clements 1985).

In Feature Geometry segments are no longer bundles of unordered features but **feature trees** (trees of hierarchically organised features).

Organisation of features (post-SPE)

Major class features

[± consonantal]

[± sonorant]

Laryngeal features

[± voice]

[± spread]

[± constricted]

Manner features

[± continuant]

[± nasal]

[± lateral]

Place features

[labial]

further divided into [± round]

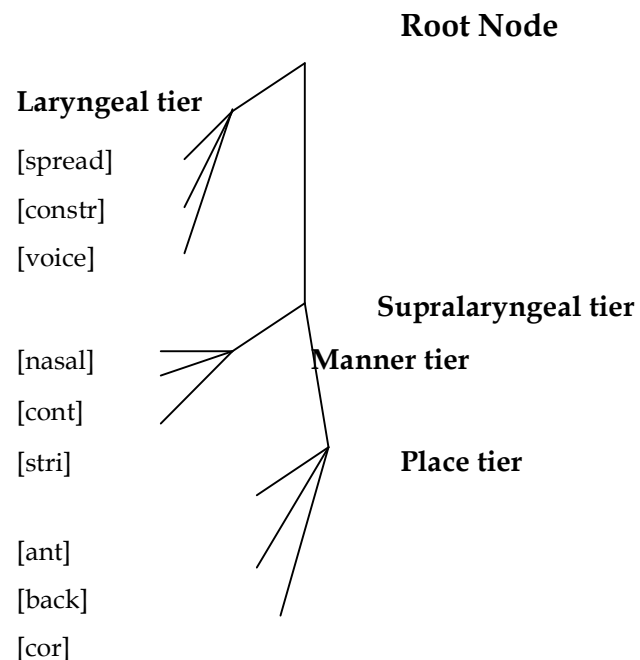
[coronal]

further divided into [± anterior]
[± distributed]

[dorsal]

further divided into [± high]
[± low]
[± back]
[± ATR]

The following tree was the original feature tree proposed by Clements (1985):



Issues bearing upon organisation of features, appropriateness of nodes etc. instigated a fruitful debate over the years and different versions of this original tree have been proposed (among others Halle 1992, Keyser & Stevens 1994, Clements & Hume 1994).

Rules and Representations

A. Rules & Representation - General

Phonological representations: fully specified feature matrices

Phonological rules: express relations (changes) between representations. A rule maps **underlying representations** onto **surface representations**. More than one rule can apply for mapping to be complete as in the following example from Somali below where *intermediate representation levels* appear (see examples from German, Finnish, French and English below):

underlying representation

/gabd+ta/□

□	
epenthesis	gabadtə
intervocalic weakening	gaβadtə
coronal cluster reduction	gaβada
surface representation	[gaβada]

The above set of representations derived from *linear rule application* is called **derivation**.

Rule ordering is crucial in the Somali example above. If we apply the rules in a different order the wrong surface representation will be derived.

B. Rule format

SPE or **linear** rule format:

X	→	Y	/	W ___ Z
Focus		change	/	context ___ context

Segments should be specified *minimally* (only essential and no redundant features should be included)

e.g. Below is an example of *final obstruent devoicing* in Dutch:

[-son] → [-voi] / ___ #

Rules are language-specific but may reccur in different languages.

The rule format in autosegmental phonology became **multi-linear** (see above).

C. Types of Rules:

1. **Structure Building** Rules (Redundancy Rules)
2. **Structure Changing** Rules (segment/feature changing rules)

Assimilation	(/sintaksi/ → [sindaksi])
Dissimilation	(/plek+to/ → [plexto] <i>continuanacy dissimilation</i>)
Weakening or lenition	(/las casas/ → [lah casah])
Strengthening or fortition	(/matia/ → [maθca])
Insertion (epenthesis)	(/kis-z/ → [kisɪz])
Deletion	(/pətit nəvø/ → [pəti nəvø])
Metathesis	(/ka+ʔsa/ → [kasʔa])

Deletion

X → ∅

Insertion (epenthesis)

∅ → Y

Metathesis (transformational rule format)

e.g. In Hanunoo sequences of a glottal stop and a consonantal segment are not tolerated and are reversed:

ka+ʔsa → kasʔa (not *kaʔsa)

[+syll] [+constr] [-syll] [+syll]

1 2 3 4 → 1 3 2 4

D. Ordering relations

Feeding

Rule A *feeds* rule B if rule A creates a context for rule B to apply (A feeds B; B does not affect A).

e.g. in Finnish intervocalic consonant deletion *feeds* diphthongisation:

underlying representation [] [] teye[]

intervocalic C deletion tee

diphthongisation tie[]

surface representation [] [] tie[]

[]

Counterfeeding (A does not affect B; B counter feeds A)

In French scwa deletion *counterfeeds* final consonant deletion:

1.

underlying representation

/pətit nəvø/

final C deletion (before a word-initial consonant: C → 0 / __ # # [+cons])

pəti nəvø

word-final ə-deletion

non-applicable

surface representation

[pəti nəvø][]

2.

underlying representation

/pətit-ə njes/

final C deletion (before a word-initial consonant: C → 0 / __ # # [+cons])

non-applicable

word-final ə-deletion

pətit njes[]

surface representation

[pətit njes]

If were ordered word-final ə-deletion before final C deletion we would get the incorrect surface form *pəti njes.[]

Bleeding

Rule A *bleeds* rule B if rule A prevents rule B from applying (A bleeds B; B does not affect A).

e.g. in English ɪ-epenthesis *bleeds* devoicing:

underlying representation	/bæk+z/	□	/kɪs+z/	□	/aɪ+z/	□
ɪ-epenthesis	--		kɪsɪz	□	--	
devoicing	bæks		--		--	
surface representation	[bæks]	□	[kɪsɪz]	□	[aɪz]	□

Counterbleeding (A does not affect B; B counterbleeds A)

In some varieties of German postvocalic spirantisation of voiced stops *counterbleeds* word-final obstruent devoicing:

underlying representation	/tag/
postvocalic spirantisation of voiced stops	tay
word-final obstruent devoicing	tax
surface representation	[tax]

Prosody: syllable structure and stress

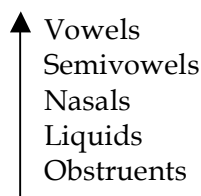
A. Syllables

The syllable as a phonological constituent was absent from the Sound Pattern of English (1968). However, it was soon after reintroduced in the phonological theory by Fudge (1969).

It is now widely accepted that suprasegmental organisation groups segments (or phonemes) into **syllables** (a hierarchically higher level of organisation).

There is no agreed phonetic definition of the notion 'syllable'. Pike (1943: 116) defines a syllable as "...a single unit of movement of the lung initiator [...] which includes but one crest of speed." However, he also suggests other criteria for the definition of a syllable, such as "relative loudness of the phonemes, sonority, prominence (made up of some of these), and change in stress or pitch" Pike (1943: 54).

The syllable has been defined by many on the basis of **sonority** ("The sonority of a sound is its loudness relative to that of other sounds with the same length, stress and pitch" Ladefoged 1982: 221). Classification of sounds in terms of their sonority relative to each other - **Sonority Hierarchy / Scale**:



The above concept relates to the definition of the syllable in that sonority *peaks* in the centre of the syllable (nucleus) and is lower at the edges of the syllable (left edge or **onset** / right edge or **coda** – see section 3 below). In fact, it is often the case that the

onset is of *rising sonority* while the coda is of *falling sonority*: e.g. [blaɪnd], [graɪnd], [trʌst] etc.[]

1. Evidence for psychological reality of the syllable:

- Children appear to be aware of syllable structure.
- Linguistically naïve speakers usually agree on number of syllables a word consists of.
- Syllables can be separable in speech.
- Syllables are countable.
- Some aphasics are incapable of pronouncing certain words but remember the number of syllables and word stress (Jakobson 1968).

2. Functions of the syllable

Fudge (1969):

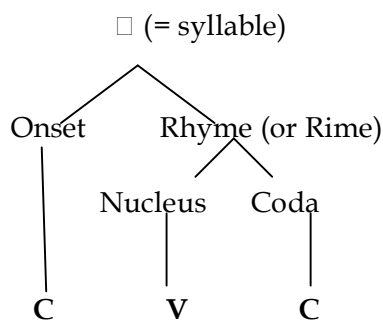
- 1) to provide a basis for distinctive prosodic features
- 2) to account for constraints on possible phoneme sequences

Selkirk (1982) added: Only via the syllable can one give the proper characterisation of the domain of application of a wide range of rules of segmental phonology.

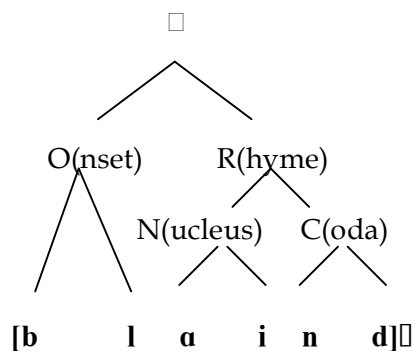
3. Theories of syllable structure

a) Onset-rhyme (onset-rime) models

There are several onset-rhyme (or onset-rime) models of syllable structure, which assume an internal hierarchical structure for the syllable which is identical or similar to the following:



An example with complex onset, nucleus and coda:



(see Fudge 1969, Kahn 1976 etc.)

Evidence for internal structure of the syllable:

Rhyming in poetry: *black ~ back* (but not *black~block*) → justification for Rhyme

Cockney rhyming slang: *apples and pears ~ stairs* → justification for Rhyme

Speech errors: *par cark (for car park) → justification for Onset

b) CV Phonology (Clements & Keyser 1983)

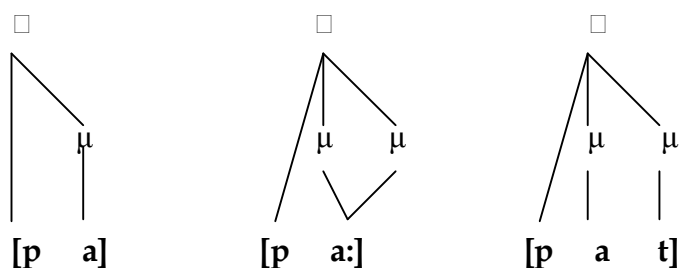
An application of Autosegmental phonology to syllable structure.

c) Moraic Theory (Hayes 1989)

Moraic theory is based on syllable **weight** and does not recognise either the onset or the rhyme (rime) constituents.

Onset elements are directly dominated by the □ node and are not assigned a mora (weight unit, represented by μ) while the nucleus and the coda are assigned morae because they contribute to syllable weight.

e.g.



4. Syllable Typology

CV: core syllable

- Present in syllable structure of all natural languages
- Learnt by children first

A range of syllable type inventories:

CV
V
CVC
VC
CCV
CCVC
CVCC
CCVCC
VCC

5. Syllabification - How is syllabification computed?

Universal Grammar (knowledge that all humans are endowed with innately) provides a mechanical way of computing the syllable structure of a word. We will

call that an '**algorithm**' (explicit and finite step-by-step procedure for solving or achieving a required end).

a) By means of a **bottom-up syllabification algorithm** (Kahn 1976): We scan a string of phonemes and compute the syllable structure which best fits them. First a rule assigns a node □ to a V, then another rule attaches all preceding consonants not exceeding a permissible word-initial cluster to V and finally yet another rule attaches all following consonants not exceeding a permissible word-final cluster to V.

e.g. How do we syllabify, say, 'kit' and 'napkin'?

i). We first identify the Nucleus in the syllable and assign it the N position. Next we identify the Onset: Consonant(s) preceding N. Last we identify the Coda: Consonant(s) following N. e.g. [kɪt] k: onset, ɪ: nucleus, t: coda

ii). [næp.kɪn], [næ.pkɪn], or [næpk.ɪn]?

According to Kahn's algorithm, after having identified the N of the final syllable in [næpkɪn] we associate consonants to the O of that syllable as many times as possible until we run out of consonants or we encounter a cluster which is illegal (**Onset Maximisation Principle**). The right syllabification for napkin will therefore be [næp.kɪn]; (pk is an illegal onset or coda in English).

b) By means of a **top-down templatic** approach (Selkirk 1984).

Template: an abstract tree structure onto which all English syllables would have to fit. A general statement (non-procedural) as opposed to an algorithm (finite step-by-step procedure for achieving a required end) about the structure of the syllable of English.

Rule ordering holds: e.g. syllabification must have been completed before stress is assigned.

B. Stress

Stress can be defined as syllable *prominence* in a certain word. It can be associated with greater *loudness, pitch, duration* and sometimes *vowel quality*.

English stress

The Sound Pattern of English (Chomsky & Halle 1968) proposed a *segmental approach* to stress, i.e. an approach in which stress was a property of individual segments (vowels) and was assigned by a set of rules. The *syllable* as a phonological constituent was absent from it and it was assumed that *strings of segments, boundaries* and *phonological rules* were sufficient to account for the phonology of English.

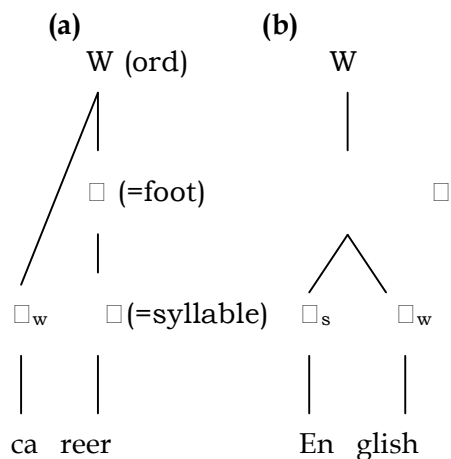
Principal features of the SPE method of stress-assignment:

1. Stress is a property of individual segments (vowels), which is assigned by a set of rules.
2. Primary stress is indicated by the feature [1stress] and absence of stress by [0stress]; all other stress values are derived by convention.
3. Stress assignment is dependent upon morphological and syntactic structure, and all and only all lexical category words must contain at least one [1stress] vowel.
4. Stress is n-ary and is assigned cyclically, working from the innermost set of syntactic bracketing outwards.

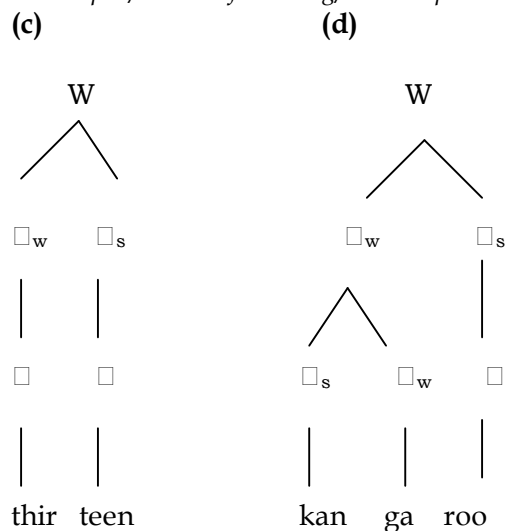
5. From (4) it follows that stress is first assigned to simple words, then to words plus (certain types of) affixes, then to compounds and to larger syntactic strings.
6. All stress assignment rules assign [1stress] to some vowel but they are of two types: a) rules which assign [1stress] to a vowel not already bearing [1stress]; b) rules which assign [1stress] to a vowel already bearing [1stress]. (from Hogg & McCully 1987)

Metrical Phonology - introduced by Liberman & Prince (1976) - proposed a *relational* approach to stress, which replaced the absolute integer values of stress assigned by SPE. Later, the initial proposal was modified to incorporate the **syllable** - which had been reintroduced in the theory of phonology by Fudge (1969) - and essentially became a *syllable-based* approach to stress.

The internal metrical structure of words is now hierarchically organised. Segments are organised into syllables and syllables are organised into feet. A **(metrical) foot** is hierarchically ordered above the syllable and can be defined as a phonological string containing at least one stressed syllable. A **trochee** is a foot consisting of one stressed syllable (head) followed by one unstressed syllable (regular foot) or zero syllables (weak or degenerate foot). When the head of the foot is at the right edge we call it an **iamb**. English has a **trochaic** stress pattern:



Subscript s/w stand for strong/weak respectively.



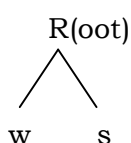
Prominence of feet is determined by rule.

As can be seen above, the organisation of a prosodic word is represented into metrical patterns, which demonstrate the relative prominence obtaining among its syllables, by means of binary-branching **metrical tree structures** with strong / weak nodes.

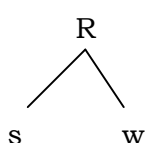
The same applies to an utterance / phrase. Here only the stressed syllable of one prosodic word is compared to the stressed syllable of another prosodic word at the same prosodic level (sister nodes are compared only!):

Stress above the word level

The pattern strong/weak applies to compounds and weak/strong to phrases:



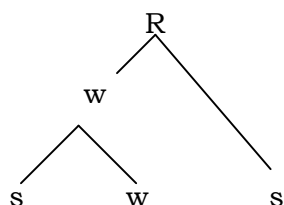
(a) black bird (*phrasal stress*)



(b) blackbird (*compound stress*)



(c) Jack left (*phrasal stress*)



(d) dew - covered lawn (*phrasal stress*)

An alternative notation, the **metrical grid**, has been used to express stress relationships.

It is a 2-dimensional device consisting of hierarchically organised parallel horizontal levels, on which there are points marking *periodicities*. Any point on a higher level will have a counterpart on a lower level, though not vice versa. It is set up as follows:

1. We mark each syllable with a '*':

* * *syllable level*
En glish

2. We mark the stressed syllable (= head) of each foot with another '*':

* *foot level*
(* *) *syllable level*

English

3. We mark the main stress of the word with yet another ‘*’:

* *prosodic word level*
* *foot level*
(* *) *syllable level*
English

The metrical grid accounts for **stress shift (iambic reversal)** in a more effective way than the metrical tree:

*		*
-----		* *
* * *	→	* * *
(*) (*) (*)		(*) (*) (*)
thir teen men		thir teen men

The two *adjacent* grid points above in bold type are metrically *clashing* because, in the next lower level, their counterparts are also adjacent. An *alternating* metrical pattern is preferred in English and this is the reason why the above string undergoes *iambic reversal*.

A basic *principle* in phonological organisation is that **words consist of (metrical) feet and (metrical) feet consist of syllables**.

Two basic *parameters* (among others) in the phonology of English are:

- In English feet are left-headed (= trochees); namely, the *leftmost* syllable in a foot is strongest: e.g. *mánnern, énglisch* etc.
- Feet are built from right to left.